METALWORK AND ENAMELLING

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A PRACTICAL TREATISE ON GOLD AND SILVERSMITHS' WORK AND THEIR ALLIED CRAFTS BY

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WITH 333 LINE DRAWINGS
BY CYRIL PEARCE, AND
OTHER ILLUSTRATIONS

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W. G. COLLINGWOOD, M.A., F.S.A.

THIS VOLUME IS AFFECTIONATELY

DEDICATED

PREFACE

In this book metalwork and enamelling are discussed from the essentially practical and technical standpoint, rather than from the artistic or historical point of view. I have taken a different course from that followed by many writers on the subject, in that, instead of describing the making of a brooch, a cup or a casket, I have so planned the book that soldering, raising, stone setting, enamelling and the other branches of the work are treated in separate chapters. I have tried to describe as simply and definitely as possible each process; and, by grouping all that I have to say upon it in one or more consecutive chapters, I have been able to treat it in a more comprehensive and, I hope, useful manner than if the details of the process concerned had been spread in scraps throughout the book. Thus, the chapters on soldering give, I believe, a more complete and practical discussion of this important subject than can be met with elsewhere. They may therefore appeal to workers in other crafts than those to whom they are primarily addressed; as also may the chapters on design, the making and sharpening of tools, raising, spinning, metal-casting, metal-colouring, setting out, and the various tables and standards at the end of the book. In Chapter XXXVI an attempt has been made to bring order out of the chaos which reigns in England as to the gauges employed in measuring metals and other materials.

It is perhaps too much to expect that no errors have crept into this work, or that better methods than those given in the book may not in some cases be practised. I have, however, in every case described the method I have employed—the best method known to me; and I should be glad if

those who have a fuller knowledge would care to communicate it to me at the address given below; or care of the publishers.

My thanks are due to Mr. Alfred J. Davis, goldsmith and jeweller, of London, for much valuable assistance and criticism in the preparation of this work; to Mr. H. S. Brown, goldsmith and jeweller, also of London, for his never-failing readiness to help; to my old master and friend, Mr. R. Catterson Smith, headmaster of the Birmingham Municipal School of Art, for the material which I have used in Chapter XXXII; to Sir Cecil H. Smith, LL.D., Director of the Victoria and Albert Museum, South Kensington, for permission to reproduce the Greek bowl shown in Fig. 368; to Messrs. Ramsden and Carr, silversmiths, of London, for the reproductions of the mace shown in Figs. 362–3; to my colleague, Mr. Cyril Pearce, for the skill and care with which he has prepared the line illustrations to the text; to Mr. Charles Lowen, of London, for some excellent photographs from works in the British and Victoria and Albert Museums, taken specially for this work; to the authorities of those institutions for their invariable courtesy and helpfulness; and to Mr. C. A. Sadler, D.Sc., and my other colleagues at Reading for assistance in many directions.

HERBERT MARYON.

University College,
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CONTENTS

CHAPTER VIII

CHAPTER IX

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

CHAPTER XV

CHAPTER XVI

CHAPTER XVII

CHAPTER XVIII

CHAPTER XIX

CHAPTER XX

CHAPTER XXI

CHAPTER XXII

CHAPTER XXIII

CHAPTER XXIV

CHAPTER XXV

CHAPTER XXVI

CHAPTER XXVII

CHAPTER XXVIII

CHAPTER XXIX

CHAPTER XXX

CHAPTER XXXI

CHAPTER XXXII

METALWORK AND ENAMELLING

CHAPTER I

MATERIALS AND TOOLS

Gold and silver—Care of material—Assay—Copper and brass—Other metals and alloys—The workshop—Various tools.

GOLD and silver may be purchased from many dealers in jewellers' materials, either in the pure or in the alloyed state, in sheet, wire and granular form. The sheet metal is generally kept in a coiled strip, perhaps 6 or 12 inches wide and of considerable length. But sheets can be rolled to any size or thickness. The surface is generally free from scratches and blisters. Wire can be obtained of almost any size and section. Gold and silver are sold in the granular form for casting or alloying. They may also be had in the form of tube or "chenier." This can be obtained with a soldered join up the side, or seamless; the latter variety being very useful for joints and hinges. Solid or hollow mouldings, hollow beads, chains, snaps, swivels, mounts, settings for stones, blanks for rings and other similar things are kept in many different designs, and in several qualities.

Owing to the cost of the material a number of precautions are taken in the workshop against the loss of any portion of it, however small. The bench is swept several times a day with a hare's foot, which forms a convenient little brush to which the gold will not adhere. All filings—lemel is the technical name for them—are carefully preserved. The residue from the polishings, the dust from the floor, and even the sediment from the water in which the men wash their

hands, are carefully dealt with. The mud and dust are taken to a refiner's, and he recovers the precious metal from them.

Sometimes dirt or some other foreign matter gets mixed with gold, and makes it difficult to work. To clean the gold—melt it in a crucible and add to it corrosive sublimate (bichloride of mercury, $HgCl_2$). Avoid the fumes. To clean silver—say you are melting down lemel (filings),—add saltpetre to the molten metal, and when it boils up, throw a little common salt into the skittle-pot or crucible in which it is. This will cause it to subside. The dirt will come away with the flux.

There are two methods by which it is possible to ascertain the quality of gold in any article. The first is by the "touch" or black stone. This is a hard black stone. The gold to be tested is rubbed along it, leaving a streak. The colour of this streak, or touch, is compared with that made by a small bar of known quality, known as a touch needle. Touch needles are made for each carat. The streaks on the blackstone are, after examination, washed over with nitric acid, and again compared. The quality of the gold may in this manner be roughly ascertained.

But a much more accurate method is generally adopted. A description of this process, taken from Mr. Cripps' valuable book on *Old English Plate*, is as follows:—

"For gold, to a portion of metal scraped off the article to be examined, say about eight grains, after being accurately weighed, is added three times its weight of silver, and a proper proportion of lead, the latter by wrapping the gold and silver in a piece of sheet-lead. The whole is placed in a small shallow porous crucible made of bone ashes, called a cupel, and exposed to a bright-red heat; the metals melt, and whilst the silver and gold combine, the lead and alloying metals become oxidised, and the oxides are absorbed by the cupel, leaving a button of pure gold and silver. This button is then flattened, rolled out into a strip, which is then coiled into a sort of screw, called a 'cornet'; this is placed in hot

diluted nitric acid, by which the silver is dissolved and the gold alone remains, the cornet is then treated with stronger nitric acid, washed, and lastly made red-hot; when cold it is weighed again, and the difference between its present weight and the original weight of the scrapings carefully determined. For silver the process is much the same: a certain portion, usually about ten or twenty grains, is scraped off the article, some being taken from each separate part: this is wrapped in lead of proportionate weight, and the whole heated in the cupel. The result is the same as in the case of gold, except that the button remaining is of pure silver only; the difference between the weight of this button and the original weight of the portion operated upon, shows the amount of alloy. The portion of metal taken off for examination is called the 'diet.'"

Copper, brass, etc., are supplied in rolls, many yards long, of any width up to 12 inches or more. They are also kept in sheets measuring 48 × 24 inches. Their surface varies much in quality, some sheets being badly scratched and blistered. Perfectly smooth metal may, however, be procured. The sheets may be had in soft annealed finish, hard-rolled, or burnished. For raising or repoussé work the first should be chosen. Copper and brass are also supplied in the form of strip, wire and rod. There is hardly any limit to the size or variety of shape in which these are made. Seamless copper tubes up to six inches or greater diameter are to be met with. They are useful for a number of purposes where a join up the side of a vessel would be objectionable. A length of the tube can, of course, be hammered and shaped in the manner described in Chapter XI. A considerable saving in time may be thus effected. Mouldings and hollow beads of various shapes are also kept ready made. Gilding metal and the various bronzes and brasses can also be had in a variety of forms. Among the other metals or alloys employed are—

German silver. Good white colour. It is a hard, springy material to work in.—Nickel. Greyish-white colour. It

spins well. Has a strong magnetic property.—Cobalt is very similar in colour, but is too hard to work comfortably.—Aluminium. Good for raising and spinning. Joints should be riveted, as no aluminium solder seems to make a quite permanent joint.—Pewter. Very soft and easy to work.—Tin. Very similar to pewter, and often employed in its place.

The arrangement of the workshop varies considerably according to the kind of work to be undertaken. For large work the bench should be about 2 feet 10 inches high; the top being of hard wood, and at least 2 inches thick. It should be firmly fixed to the wall. The vice should not weigh less than 65 lb. If lighter, it will vibrate too much when raising is being done. The soldering hearth is described in Chapter III. The gas supply pipe should measure not less than half an inch clear bore. A pipe with three quarters of an inch bore is better, for unless you get a good supply of gas you may have difficulties in getting the work hot enough. Get a good-sized blowpipe also. Fletcher's No. 5 Bellows are large enough for most purposes. The lathe is mentioned in Chapter XII. It need not be back-geared. A slide rest, a drill chuck, and a face-plate with dogs make it an extremely handy tool for the many odd jobs which turn up in the course of the work. A number of wooden chucks should also be provided. A surface plate is a rather expensive tool, but it is useful in trueing up work which has to stand or fit accurately. A good piece of plate glass will make an excellent substitute, however. The grindstone should be mounted with treadle and drip can. A large, smooth slab of stone is useful for grinding smooth the rims of bowls and other vessels after they have been filed as truly as possible. The kind of stone does not seem to matter much. A smooth York paving stone answers very well. The drawbench is described in Chapter XV. The polishing lathe, Fig. 1, has a horizontal mandrel, perhaps a foot long, driven by a cord or strap from the fly-wheel. At each end of the mandrel a tapering screw thread is cut,

upon which various brushes and mops can be screwed. The polishing materials are applied to them with a stick or brush.

The jeweller's bench is described in Chapter VI. A list of the special tools required for each branch of the work will be found in the chapters devoted to it.

CHAPTER II

SOLDERING

Hard solders—Composition of gold solders—Silver solders—Spelter solders for copper, brass and iron—Moulds for casting solder.

SOLDERING is the art of joining together separate pieces of metal by running between them some other metal or alloy, which will closely adhere to their surfaces and bind them together. The metal or alloy used for this purpose is known as solder. It must have a lower melting point—require less heat to melt it—than the metal of which the work is composed, so that a temperature high enough to melt the solder will leave the work uninjured. But the melting point of the solder should approach as nearly as may be conveniently possible to that of the work, for a more perfect and a stronger joint is thus produced. "The essence of true soldering," says Mr. Hiorns, "is that there should be a certain amount of interfusion or alloying between the solder and the metal to be soldered, an intimate union of the two thus taking place."

There are many kinds of solder. They are known by such names as gold solder, silver solder, spelter, tinman's and plumber's solder. But they may be broadly divided into two groups—hard solders and soft solders. Hard solders melt at, or above, red heat, and are used for materials which can safely withstand such temperatures. But soft solders require comparatively little heat to fuse them, so they can be used for soldering almost any metal or alloy. Joints made with hard solder are considerably stronger than those made with soft. The harder solders are used generally by goldsmiths, jewellers and silversmiths; the softer kinds by plumbers and tinsmiths. Coppersmiths use

both, and, sad to relate, even goldsmiths occasionally use "soft tommy." It is impossible, without doing serious damage, to use hard solder on work upon which there is already any soft.

Before discussing the solders employed for goldwork, a few words are necessary as to the method by which the proportion of pure gold in any article is indicated. The quality of gold is expressed by the number of parts of pure gold out of 24 parts or carats. Thus pure or "fine" gold is 24 carat. If any other metal is mixed with the gold, the latter is said to be alloyed by it. For instance, 22 carat gold contains 22 parts of fine gold and 2 parts of some other metal or metals; 18 carat gold has 18 parts of pure gold to 6 parts of alloy, and so on. Gold coinage in England consists of 22 parts of fine gold and 2 parts of copper, or, in thousandth parts, 916·66 parts of pure gold to 83·34 parts of copper. This is known as "Standard" gold. The metals generally used to alloy gold for manufacturing purposes are copper and silver. The addition of any portion of these metals to a piece of gold lowers its melting point. Less heat is required to fuse it. The greater the amount of alloy added, the lower is the melting point of the mixture. It will be obvious then that the quality of the gold, whether fine or 22, 20, 18, 15, 12 or any other carat, is a clear indication as to its relative melting point. So, any gold may be used as a solder for a better quality gold. Thus 12 carat gold will act as a solder for 15 carat or any better quality; 16 carat for 18 or better; 18 carat for 20, 20 carat for 22 or for fine gold, and so on. But it would be, of course, impossible to solder a piece of 15 carat work with 18 carat gold; the work would melt first.

To make a solder for gold, it is only necessary to add a small portion (a fourth, fifth or sixth part by weight) of copper, or of copper and silver, to a piece of the gold which you are to use. If a small amount is required, melt them together on the charcoal till they are thoroughly mixed. Flatten out the little bead of molten metal as it begins to

cool. Drop it in pickle and afterwards roll or hammer it out to about size 6 on the metal gauge. A larger amount is best melted in a crucible, cast in a flat sheet and rolled out to the thickness required. For example, you are using 18 carat gold. A pennyweight of it contains 18 grains of fine gold and 6 grains of alloy. If you added 3 grains more of alloy then you would have 18 grains of gold and 9 grains of alloy,—two-thirds gold, one-third alloy. Now two-thirds of 24 (carats) is 16, so the mixture would be 16 carat in quality. To use 16 carat solder on 18 carat gold is not unusual, but it requires some experience, as their melting points are not so very far apart. To make an easier solder, add 5 grains of alloy instead of 3 grains, to the pennyweight of 18 carat gold. The resulting mixture will be just under 15 carat, and will prove a perfectly safe solder to use on 18 carat gold. In a similar manner the proportion of alloy to be added to produce a solder of any quality may be reckoned out.

It should be remembered that with copper as the alloy, you produce a solder which is richer in colour than one alloyed with silver, but it will not flow quite so easily. So, as a rule, both metals are used together, as in the examples given below, which are for solders made from fine gold. Always choose a solder which is as good as you can safely use on the work.

Gold Solders

	Fine Gold.	Silver.	Copper.	Total.	Quality of the Solder.
No.	dwt. gr.	dwt. gr.	dwt. gr.	dwt. gr.	
1.	1 0	0 9	0 6	1 15	Just over 15 carat.
2.	1 0	0 12	0 12	2 0	12 carat.
3.	1 0	0 16½	0 10½	2 3	Under 12 carat.
4.	1 0	0 17	0 14	2 7	Just under 10½ carat.
5.	1 0	0 19½	0 15	2 10½	Under 10 carat,
and lower qualities on the same principle.					

Pure silver is known as "fine" silver, but it is too soft for general use. It is, therefore, alloyed with copper.

The proportion of alloy in what is known as "Standard" silver, or the silver used for coinage, is 18 parts alloy (copper) to 222 parts of fine silver; or, in thousandth parts, Standard silver contains 925 parts of fine silver to 75 parts of alloy; or 37 fortieths of fine silver; or, 11 oz. 2 dwt. of fine silver to 18 dwt. of copper. This is the standard quality for "Sterling silver," and is "Hall-marked" as such. There is another standard, known as the "New Sterling" or "Britannia" standard, in which the proportions are 10 parts alloy to 230 parts fine silver, or 959 thousandths fine silver, or 11 oz. 10 dwt. fine silver to 10 dwt. of alloy. But this alloy does not wear very well, so it is comparatively little used.

Silver solders are usually made by alloying silver with copper or with brass (*i. e.* copper and zinc). Those alloyed with copper alone are harder and do not flow along the joint quite so freely as those solders of which zinc is an ingredient. On the other hand solders which contain much zinc are not quite so strong as those made from silver and copper alone, and if heated many times, the zinc which happens to be near the surface is burnt away—leaving the surface rough. This may cause trouble in finishing. Solders for work which is to be enamelled, should therefore contain little or no zinc. But for ordinary silverwork, where the ease with which a solder will flow is an important consideration, the solder may contain a fair percentage of zinc. The first solder given below is very hard, and, on account of its freedom from zinc, suitable for work which has to be enamelled. The second is extremely strong and flows quite easily. It is more expensive than the third, owing to the greater proportion of silver in it. Brass wire is used as the alloy, not scrap brass, because wire, sold commercially, is of pretty good quality, while sheet brass may not be. The composition of good brass wire is about 70% copper and 30% zinc. The third solder flows very easily indeed, but it is not so strong as the others. And, if made from pins, the difficulty of the burning out of the zinc may arise. Pins may contain from 55 to 70% of zinc.

Silver Solders

No. 1. Silver 4 parts, copper 1 part. Very hard.
No. 2. Silver 3 parts, brass wire 1 part. Good and strong,
No. 3. Silver 2 parts, brass wire or good pins 1 part. Easy flowing.

These silver solders are also used on copper and brass.

Solders for copper, brass or iron, are often known as spelter, and the process of soldering as brazing. The solder generally used is a kind of brass—made from copper and zinc. The melting point of the alloy depends upon the percentage of zinc present, so that as the proportion of zinc increases, the melting point is lowered. Occasionally small percentages of tin and lead are included, but these metals, though lowering the melting point, yet weaken the alloy, so they should be avoided. Hiorns gives the following :—

No.	Copper.	Zinc.	Tin.	Lead.	Colour.	Remarks.
1.	58	42	—	—	Reddish yellow	Very strong.
2.	53	47	—	—	Do.	Strong.
3.	48	52	—	—	Do.	Medium.
4.	54½	43½	1½	½	Do.	Do.
5.	34	66	—	—	White	Easily fusible.
6.	44	50	4	2	Grey	Do.
7.	57	28	15	4	White	White solder.

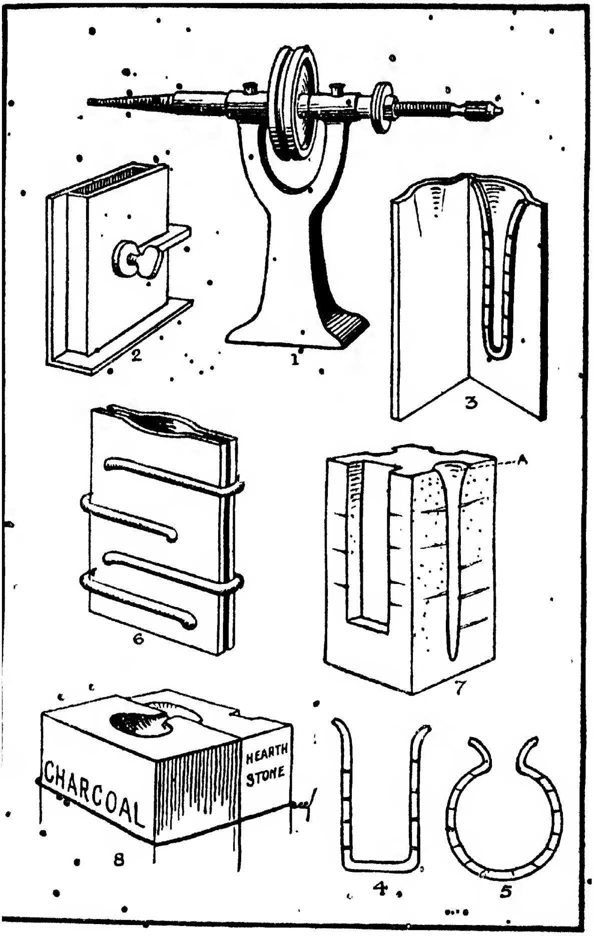
The alloy generally used contains equal parts of copper and zinc; while a very fusible solder can be made from two parts of zinc to one of copper. A solder to use with any brass can be made by taking a portion of the brass and adding to it a quarter of its weight in zinc. The best method of making brass solder is to melt the brass or copper first under a layer of charcoal. Warm the zinc to near its melting point and add it to the brass. Use common table salt, pearlash or cream of tartar as a flux. They are better than borax for this purpose. Stir the alloy well before pouring. The solder may be poured from a height into water, passing through a wet broom on its way, to break it

into small pieces. Or it may be pounded into powder in an iron mortar immediately it has cooled sufficiently to set. It is a mistake to remelt any hard solder containing zinc for the purpose of obtaining a more regular mixing of the ingredients. Some of the zinc is burnt out each time the alloy is heated, so the fusibility of the solder is impaired, not improved.

The ingredients for gold and silver solders, with the exception given below, are, when melted, poured into what are known as ingot moulds. These moulds are made in various forms. That shown in Fig. 2 is suitable for casting rectangular pieces of solder or of the metal itself. These plates or ingots may be rolled out afterwards into long strips if required. This type of mould consists of two iron plates, kept apart by a flange the thickness of the ingot required. By sliding one plate over the other the shape of the mould may be varied. The two plates are kept together by a clamp. Another convenient form of ingot mould is shown in Fig. 3. It is made from two pieces of sheet iron. The flange between them is, in this case, formed from a piece of iron wire which has been flattened by passing it through the rolls. The wire is then bent to the shape of the ingot required, in this case that of a capital U, perhaps 3 inches high, with the top ends bent out a little; in thickness rather less than ⅛ inch. By varying the shape and thickness of the bent iron wire, ingots of any form or thickness may be cast, Figs. 4 and 5. A few nicks made with a 3-square file across the flat sides of the wire will assist the escape of the air when the metal is poured in. The bent iron wire and the two plates are firmly held together by U-shaped pieces of stout iron wire slid on at intervals round the edge of the plates, Fig. 6. The mould used by jewellers for casting ingots is made from a piece of hearthstone—the white stone used for cleaning hearths. A block of this is taken and rubbed quite flat on each side. On one face a hollow is carved to the shape of the ingot required, see Fig. 7. The wide-open mouth or "pour" at A is the

way the metal is to come in. The opening is made wider here so that none gets spilt outside. Then with a 3-square file, make a number of shallow grooves across the face of the mould to let the air out. Bake dry. Take a slab of charcoal and rub one side of it quite flat on a stone. Near one end of this flattened side dig a little pit large enough to hold the metal when melted. If you now put the piece of hearthstone with the side which has been hollowed out against the flat part of the charcoal you have a complete mould, with only the little opening or "pour" turned so as to be quite close to the little pit in the charcoal. The two parts of the mould—hearthstone and charcoal, may be tied together with wire, Fig. 8. When the metal is melted, and this is done in the hollow on the charcoal, you have only to tilt the mould so that the molten metal may run into the place prepared for it. These hearthstone moulds may be made in any shape. For wire make them long and narrow, tapering to a point at the end away from the pour. This point is for convenience in getting it through the holes in the drawplate. It saves filing or hammering.

The mould having been prepared, take the ingredients for your solder, cut them into small pieces and put them into a fire-clay crucible, with a little powdered borax on top. Put the crucible in the furnace, or on to a place prepared for it on the hearth. Heat it until all its contents have melted. If you are using a metal mould, warm it well by placing it on the furnace or hearth. Just before you are ready to pour the metal, put a little sweet oil into the mould, to grease it. Stir the molten metal well with an iron rod. Some of the borax may stick to the rod, but don't, if you can help it, pick up any of the metal. Then lift the crucible with the tongs and steadily fill the mould. Avoid splashing the metal in. Put the crucible back in the furnace if there is any metal yet remaining in it. The metal in the mould will be set in half a minute. The clamps may be knocked off, the metal turned out, and the mould got ready at once for the remainder. Be careful that there


1
2
3
6
A
7
CHARCOAL
HEARTH STONE
8
4
5

is not a trace of moisture about the mould when you pour the metal into it, for it would blow up, with possibly serious results. The oil does not matter. Some borax will have collected at the top of the ingot. A sharp blow may bring it off, or the ingot may be scraped clean or boiled in pickle. Then carefully cut and file off any rough edges or stray branches that may be present on the ingot; for if you use an ingot the edges of which are rough and uneven, with thin projecting pieces, for rolling into sheet or drawing into wire, cracks will be sure to appear in it. Roll out your ingot of solder to a convenient thickness, say size 8 on the metal gauge, or thinner for very small work.

The exception to the use of ingot moulds, referred to on page 11, is that in which you wish to make a very small piece of solder. You may melt it on a charcoal block. It will run up into a ball. Flatten this as it cools by pressing any piece of iron on to it. Then hammer it out as required.

That a piece of solder shall never be mistaken for a piece of silver, or vice versa, it is a good plan to scratch a number of lines in all directions across the sheet of solder when it has been rolled to the required thickness. If this is done it can never afterwards be mistaken for sheet silver.

We have now come to the end of the hard solders. But before going on to the soft solders, we will discuss the manner in which the former are used in actual practice. But first it may be well to repeat the warning against the use of hard solder on any article on which there is already any trace of soft solder.

CHAPTER III

SOLDERING (*continued*)

Binding work for soldering—Soldering in plaster—Use of borax—Application of solder—Soldering hearth—Jeweller's charcoal and wig—Management of flame—Various hints—Removal of borax—Composition of pickling solutions—Antidote for acid burns—Brazing.

THE separate pieces of metal which are to be hard soldered together should first be bound in position with binding wire. This wire can be obtained in various sizes. No. 20 on the standard wire gauge is a good thickness for general silver or copper work. No. 28 for finer work and jewellery. No. 32 for very fine jewellery. The wire is of iron, and on no account for gold, silver, copper or brass work should it be galvanised or tinned. For the metals with which such wires are coated, when heated, would alloy themselves with the gold or other metal of which the work is composed, and make a "burnt" line which would be very difficult to remove. So make sure that you use only plain iron wire. It generally has a dull, slightly rusted surface. Both the work and the iron wire expand when heated. But unless both are heated equally the work may expand a good deal before the wire has begun to stretch. As a result you may find that in soldering say, a square box of thin metal, the wires have cut into the corners. It is not difficult to avoid such an injury to the work. You have but to make a Z-shaped kink in the wires every here and there as they pass round the box. These will allow the work to expand, yet they will not make the wires slack. In soldering the seam at the side of a tapering tube—part of a cone—some difficulty may be met with in keeping the wires which tie it together from sliding towards the smaller end, and so working loose,

To prevent this take three lengths of wire and make kinks or knots at intervals. Then put these wires lengthwise of the tube, clipping their extremities round its open ends. Wires tied round the tube will not now slip down, for they cannot pass the kinks.

Sometimes it is impossible to tie work together with binding wire. The shape of the parts may prevent it. For instance, a number of wires or other thin pieces radiate from the point at which they are to be soldered. Or grains and narrow cloisons are to be fixed upon a background. In the former case fix the wires accurately in position on a piece of wax. Plasticine or any other material which would tarnish the metal must not be used, for metal so tarnished is almost impossible to solder. Wax can be bought from any dealer in jewellers' materials. When fixing the wires in their positions tuck under each one of them a tiny V-shaped loop of binding wire, leaving the ends of the wire projecting above the wax. These little wire loops should be made from ¼ inch lengths of thin binding wire. Put one of these little loops under each wire or boss as it is being stuck down in position on the wax. When all are arranged paint borax over all the joints which have to be soldered. Then mix a little plaster of Paris and pour it over the work. When set, the wax may be removed. The little loops of binding wire, with their ends firmly fixed in the plaster, will keep all the parts in place. Now clear away any plaster which may interfere with your soldering. Thoroughly dry the plaster. Add a little more borax wherever necessary and solder in the ordinary way. Grains or cloisons may be fastened down on to a background with gum. This should be mixed with borax. It is a good plan to keep a lump of gum on the borax slate, and rub a thick paste of it for use in sticking down these small pieces. Dry this thoroughly. Then go over the joints again with ordinary borax before soldering. But for further particulars of this work see Chapter VII, on Filigree. There are so many things to think about in wiring up any work for

soldering that it is difficult to give general rules. Each case must be decided on its merits.

All the metals used by the jeweller and silversmith, with the exception of pure gold, become oxidised when heated in air. A thin film of oxide forms on the surface. With copper this film is a dense black scale. All the alloys of copper, and they are many, show some trace of this oxide, with others. To solder work, however, it is necessary that the surfaces to be joined shall be clean and bright, even when red hot. To keep them clean they must be covered with some substance which will exclude the air. A substance which does this is known as a flux. Now for hard solders borax performs this duty splendidly. It is generally used in the lump form, not the powder. The lump of borax is rubbed with a little water on a small piece of slate. It grinds up into a white creamy paste which can be applied to the joint with a brush or feather. If several joints are to be soldered at the same heating put borax on them all. Then all of the joints will keep clean until you are ready to solder them. If you put borax only on the first you would have to cool the work down, and thoroughly clean the other joints before you could solder them, for a joint will not keep clean when the work is heated unless it is boraxed. Take care to work the borax well into the crack. Joints should be as close as possible, though the solder will fill a crack as thick as a sheet of writing paper. Should it be necessary, however, to solder up a wider gap it is well to plug it first with a scrap of metal. Borax, when heated, first boils up in a white scum, then it subsides and melts into a hard transparent substance, known as borax glass. In certain kinds of work, in which this boiling up of the borax might cause trouble, by moving parts out of their true position, the difficulty is got over in another way. Gum tragacanth is mixed with the borax on the slate, to keep the parts in place. Or, instead of lump borax, borax glass is used. It is ground with vaseline instead of water, and used in the ordinary way. It does not boil up at all.

The solder will follow the borax, but it will not flow where there is no borax. If, however, there is some place upon which you particularly do not wish the solder to go, you may cover it with rouge, loam, whiting or tripoli, or a mixture of any of these, as an extra safeguard.

With the borax the solder may be applied. It should first be cut into pieces of convenient size. This may be done by making a series of parallel cuts 1 inch long and $\frac{1}{8}$, $\frac{1}{16}$ or $\frac{1}{32}$ of an inch apart, at the extremity of your piece of solder. It has already been rolled down to a convenient thickness. Then holding one finger against the sheet of solder, touching the ends of all the little strips, make another series of cuts at right angles to the first set. A number of tiny square or oblong pieces, or "paillons," of metal will be separated at each cut. They would fly all about if you had not your finger against them. Drop them on the borax slate or into a little box specially kept for them. Take very great care that no pieces of gold or silver, or any other material than just this solder, gets mixed with them. They might cause serious trouble. With the tweezers place a number of these little pieces at intervals along the joint or crack to be soldered. They should be sufficient in bulk to fill the crack. Not more, or you would have afterwards to file off the superfluous amount. It would otherwise make the work look heavy. If, when the solder has been melted, you find that the crack is not sufficiently filled, it is quite easy to add a few more pieces of solder. To do this before the work has cooled down, with the tweezers dip each piece of solder into the creamy borax and place it in position, holding it down till the borax has boiled up. The solder will then keep firmly in position. If you omit to hold it down the borax may carry it, when it boils, right away from the joint. Another method of applying the solder, much favoured by silversmiths, is that in which the solder is first cut into long strips, perhaps $\frac{1}{8}$ inch wide, and held in the left hand with pliers. When the work is sufficiently heated the point of the solder is

touched on to the joint where required. Some of the solder melts instantly and flows into the crack. One advantage of this method is that the solder is not exposed for long to the heat of the flame. For the fusibility of solder is always impaired by long-continued heating, generally owing to the burning out of some of the zinc which it contains. Another advantage is that there are fewer marks left on the work where the solder rested before it melted. "Paillons" of solder generally leave a trace or "tail" to mark their temporary resting-place. But strip solder cannot be used for very small work, owing to the danger of disturbing the various parts, a difficulty which does not occur with larger work, which can be firmly tied together. Another form in which solder is used is that of powder, for soldering filigree work, described later.

Large work should be placed on a hearth for the process of soldering. The hearth is an iron tray resting on a stand or bench about 3 feet high. The tray is fixed on a pivot, so that it can be rotated when necessary—a very great convenience, for in soldering it is often necessary to turn the work round. The tray is filled with coke or pumice stone broken to about 1 or 1½ inch fragments. For the reason already given, take care that not even the smallest fragment of soft solder is allowed on this hearth. It is necessary in some cases to have a perfectly level surface upon which to rest the work during the process of soldering A most convenient slab for this purpose can be made in the following manner. Take a number of pieces of pumice stone and rub one face of each piece flat on a rough stone. Put all the pieces on a board with their flattened sides downwards. Arrange the pieces as closely together as possible, covering a space 9 inches square. Make a rim round about them from pieces of board 1 inch high. Then mix a bowl of plaster of Paris. To do this, fill the bowl one-third full of water. Sprinkle the plaster in by handfuls. Soon it will begin to show above the water in the middle of the bowl. Go on adding more plaster round the

edges until the water will only absorb the plaster slowly. Let, all the plaster sink in and then thoroughly stir the mixture for a good half-minute, taking care to get no more air-bubbles into the plaster than you can help. The plaster will now be of the consistency of cream, not quite thin like water feels. Take in your hand a little at a time of the liquid and throw it over the lumps of pumice stone. Try to fill the gaps between the lumps very thoroughly. You must be quick about this part of the work, as the plaster may be set in two or three minutes. When you have filled in all the gaps fill up all over, quite level. If you have been quick about the first part of the filling the plaster will still be liquid enough to use. You must not pour the plaster in at first, or the pieces of pumice would float out of their places. Level off the top with a straight piece of wood. Leave the work now and wash out the bowl before the plaster left in it has set hard. In five minutes the slab should be set, and feel warm to the touch. If quite hard knock off the wooden rim, and give the board upon which it rests a few blows with a mallet. The slab of plaster and pumice will then separate from it. Turn the slab over. Next fix it with plaster, mixed in the same way, into a shallow tray of sheet iron—not wood. You have now a slab with a smooth face of pumice stone, which will last for years. When thoroughly dried you can do upon it all the hard soldering that you wish. Its flat surface gives a very even support to work laid upon at for annealing or soldering. A sheet of asbestos, resting on any flat surface, may be used instead.

When, however, a piece of work rests flat on a slab, and the flame from the blowpipe cannot reach its under side, the work takes a considerable time to get red hot. A few pieces of iron wire, or better, broken pieces of piercing saws, are laid between, to lift the work clear of the slab. Work, however, which does not require this even support is annealed or soldered on the loose pumice, coke or charcoal in the hearth.

Jewellery, as a rule, is soldered upon a flat piece of charcoal held in the hand, or upon a jeweller's "wig" or "mop," Fig. 34. This is a mass of fine iron wire, bound together, with a more or less level surface. It also is held in the hand. Very small work is sometimes placed on a thin piece of sheet iron, perhaps 1 inch square, laid upon the charcoal.

When using any of the hard solders you must bear in mind that the whole work must be made fairly hot before the parts near the joint to be soldered can be raised to red heat. For if a considerable part of the work is cold it will take away much of the heat, wherever you may have directed the flame; the exception being that with a long or thin piece of work one can sometimes bring the parts near the joint to the required temperature before much of the heat has had time to run away. But as a rule one works all over the article with the flame, watching carefully that no thin or exposed part gets too much heat, until the whole work is dull red. This you can tell easily if you move the flame right off the work every now and then. Any red-hot part will show at once. Then, with a few sharp blasts, the point of the flame being directed towards the joint, that part is raised to so high a temperature that the solder flows like water along and into it. Cease blowing or move the flame away immediately, or the temperature may rise so high as to melt part of the work also. Remember that a thin or small piece will get hot much quicker than a heavier piece. So if you are soldering large and small pieces together, watch carefully lest a small piece gets dangerously hot while the heavier parts are comparatively cool. To solder, say, a light setting on a large piece of work requires some judgment. For, to raise the work to a sufficiently high temperature may take minutes, yet a single sharp blast would be sufficient to melt the setting. The secret lies in keeping the heat away from the smaller piece and in playing on the large piece only. Thin projecting pieces or thin parts may be protected with a coating of loam, rouge, whiting or a mixture of any of these,

Remember also that to make a sound joint both parts must be at about the same temperature. Otherwise the solder will flow and hold to only that which is the hotter. In soldering a long joint the tang end of a large file, held in the left hand, can be used to stroke the molten solder along. But as a rule the solder will flow towards the point which is hottest, if there is sufficient borax. Do not forget, in arranging the work on the hearth for soldering, that molten solder is a liquid, and therefore runs downwards more freely than upwards. Copper may be raised to nearly a white heat before it will melt: brass, however, goes much sooner—at a yellow heat. Silver looks pink when "red-hot" and the flame has been moved away. It will melt before it gives a white glow. Gold changes colour very little before reaching its melting point, but then it collapses very suddenly. So use considerable care, and manage your flame so that no thin part gets a sharp blast. Remember to move the flame right off the work for a fraction of a second every now and then. You will thus be able to see easily when any part is getting red hot.

To ensure a good joint, the one great rule is—cleanliness. All the surfaces should be chemically clean before the flux is applied. In some cases, when for example a sheet of gold is to be backed with silver, and the failure of the soldering at any place might have serious consequences later on, the work is treated as follows. The surfaces are cleaned by boiling them in diluted acid, afterwards in a solution of washing soda and water, and again in clean water. The surfaces should not afterwards be touched by the hand, for that might leave a trace of grease, but they should be immediately painted carefully with the borax solution and tied together with stout iron wire. The solder is laid along one long edge and one side. The work is now heated, and the solder may be drawn right through the joint. When the borax has been removed, the combined sheet is rolled as thin as may be required. If the joint is sound no blisters will be formed between the two parts of the plate.

In soldering a wire on to another part of the work you may have some difficulty in keeping the solder from running on to and thickening the wire. This is a particularly disagreeable habit, for it quite ruins the appearance of a twisted or plaited wire if it is clogged up in this way. To avoid this difficulty you must take care that the heat reaches the wire only through the work—not directly from the blowpipe itself. The heat may be applied underneath, for example, so that the flame does not touch the wire at all. The work will then be the hotter of the two, so the solder will not rush to the wire. Another method is that of running solder over the surface of the work where the wire is to come, and afterwards putting the wire in place, boraxing and reheating till the solder flows and grips the wire.

To solder the two halves of a ball, or bead, together. Inside, round the rim of each half put borax and solder. Heat each half separately so that the solder flows right round the edge of each half ball. Now rub or file the rims quite level, borax each half, tie the two together. and heat until the solder runs through the joint. You may be quite certain that by following this method you will always get a sound joint. Do not forget that you must always leave a hole for the escape of the air when soldering up any bead or other hollow article. If you omit to leave one, the pressure of the heated air inside when soldering may burst the work. Cases have occurred where jewellers have lost their eyesight through neglect of this simple precaution.

To unsolder a piece of work. First think how you can manage to separate the parts when the solder is melted. You may be able to lift or knock off the loose piece with the tongs; or you may so arrange it that the parts will spring or fall open. You may find that instead of lifting the piece off, you would lift the whole work instead. In such a case tie the work down and perhaps fix another wire to the loose piece, by which you may pull it off. Paint the joint well with borax and apply loam, rouge or whiting to any parts

or joints which are not to be disturbed. Then heat the work till the solder runs, and immediately remove the loose piece.

To remove the borax after soldering various "pickles" are used. For gold a solution of nitric acid and water is made to boil in a porcelain bowl, and the work left in it until all the melted borax has disappeared. Eight parts of water to one of acid is a good proportion to use. The boiling solution dissolves also any alloy (copper or silver) which may be present on the surface of the gold. It will also remove lead, should any of this material be present. So the work when it leaves the acid has an exterior of pure gold—the alloy having been removed, but to an infinitely small depth. For silver or copper a solution of sulphuric acid (vitriol) is used. Say 6 to 10 parts water to 1 of acid. The colour of silver after pickling is pure white.

In mixing these solutions remember that if you pour water into acid you will probably have an explosion and receive some damage. While if you pour acid into a much greater bulk of water nothing will happen except that the water will get warm from chemical action. The sulphuric acid solution is generally put into a copper bowl or pan with the work, and heated till it boils, when the borax will have been dissolved. Avoid any splashes, hot or cold, from these solutions. They burn holes in clothes, and may make serious burns on flesh. If you receive a splash, wash the part immediately with plenty of water. And, if necessary, apply a mixture of whiting and olive oil to the part. Common washing soda rubbed on the place after washing will do instead. It is usual to keep pickle in a large pan of glazed earthenware, or of lead. The solution acts more slowly when cold, but if work is left in it for an hour or two the borax will be dissolved. Large work, for which you may not have a big enough copper pan, can be cleaned in this way. But you can hasten the process by repeatedly heating the work and plunging it while red hot into the solution. The oxides formed on the surface of copper by heat are also removed by the acid solution.

Work which has been in pickle should always be washed thoroughly in plenty of water immediately it is removed from the solution. If there are any hollow parts to the work it is usual to boil it in soda and water to remove any trace of the acid. If you do not take this precaution, some of the acid which has got inside will run out or dry out in crystals later on and cause trouble. Binding wire should always be removed from the work before it is pickled.

It is well to remember that solder will not melt, until the heat is raised to a dangerously high temperature, unless borax is in contact with it. So, when a work has to undergo several successive solderings—and it may have to "go through the fire" twenty times or more—it is usual to boil it out after each soldering, to remove the borax from the joints already made. As a further protection a coating of loam, whiting or rouge may be painted over any joint which you wish to remain undisturbed.

To join pieces of copper, brass, iron or steel together by brazing, first fit the pieces together closely, and bind them with iron wire. This should not be thinner than that of which an ordinary (brass) pin is made. It may be a good deal thicker if the work is heavy. Apply borax in the ordinary way (p. 17) or in the form of powder. Then put some brass spelter or wire on the joint. Brass wire makes a good solder for iron or steel, but it would be dangerous to chance it on brass, unless you knew pretty accurately the composition of both brasses. Make sure that the wire or spelter will not move away or fall off when the borax boils up. The wire may be bent round the joint or bound in place with iron wire. Build the coke round about the work and heat until bright red, nearly white hot. The spelter or wire should melt, follow the borax and run into the joint. Should it not run easily add a little more borax. When cool the borax may be removed by pickling or scraping, and the joint filed smooth. It will show up as a faint yellow line against the grey iron.

CHAPTER IV

SOLDERING (*continued*)

Gas—Jeweller's jet—Blowpipes—Bellows—Management of blowpipe flame—Spirit lamp—Blowlamps—Coke fire—Charcoal fire—Furnace.

COAL-GAS is the simplest and most generally available fuel for the purpose of soldering. It is employed in a rather different manner for small and for large work. For jewellery and other small articles a jeweller's jet and a mouth blowpipe are the tools used. While for large work a blowpipe, Fig. 9, and bellows, Fig. 10, are necessary. The jeweller's jet, Fig. 12, is a small iron stand through which the gas-pipe passes to a horizontal tube, 4 or 5 inches long, pivoted at one end above it. The horizontal tube can be swung right round the pivot, and the gas supply is so arranged that when the tube, or jet, is in the position for soldering a full supply of gas can pass through it, while, as it is turned round out of the way, the supply is automatically cut down until only sufficient remains to keep the jet alight. The end of the tube is cut off at an angle of about 45°. The iron stand is generally fixed to the bench on the right-hand side of the worker. The mouth blowpipe, Fig. 11, used in conjunction with this jet, is a tapering tube of brass about 8 inches long, the smaller end being bent round at right angles. The tube varies in diameter from about ¼ inch down to an opening large enough to just admit an ordinary pin. A second blowpipe with an opening about twice this size is useful for rather larger work. For large work, however, the blowpipe and bellows must be used. The blowpipe in this case consists of two concentric tubes, measuring perhaps ⅜ and ⅛ inch in diameter respectively. They are bent round to nearly right angles at one end, like the mouth blowpipe. The outer

tube is for gas, the inner for the compressed air from the bellows, the supply of both being regulated by a tap. In choosing a blowpipe see that you get one with plenty of room through the taps. You should have a bore of ½ inch all the way from the main to the mouth of the blowpipe, which, however, may be a little smaller. The bellows most generally used are those known as Fletcher's No. 5. They are worked by the foot. On the underside of the bellows is an india-rubber disc, or rather two discs, covered by a net which prevents them from expanding too far. Their purpose is to make the blast continuous, for one which came in puffs would not be always satisfactory. These rubber discs sometimes burst, and it is well to know how to replace them. It will be found that the net is held on by a wire running round its circumference. Untwist the join and the net will come off. The two rubber discs are fastened on with a twisted wire in the same way. Remove them and see that the valve underneath is working well. Put on the new discs and be careful in fixing the wire that you smooth out every pleat round the edge of the rubber. Remember to bend the ends of the wires out of reach of the discs when they are expanded. You don't want to puncture them. Replace the net as before.

We come now to the management of the blowpipe flame. Let us take the jeweller's jet first. If you light the jet and turn it round till full on you will have a loose, flickering flame about a foot long, blue at the bottom and white nearly everywhere else. Turn it down till the flame is about 6 inches high. Now take the mouth blowpipe in your hand. The larger end is tinned, to be clean for the mouth. Keep the cheeks inflated and try to blow a gentle, continuous stream of air through the pipe. With a little practice the blast need not stop even while you take a fresh breath into your lungs through the nose. Do not blow too hard; quite a gentle blast is required, just as though you were whistling to yourself. When you have had a little practice with the blowpipe move its small end to a position immediately over the

horizontal tube of the jet, and about ⅜ inch from the end where the flame is. Turn the blowpipe to such an angle that the flame is blown downwards to the left at about an angle of 45°. The character of the flame will be quite changed. Instead of being nearly white it will be blue, with some flashes of white towards the point. The jet of air has both altered the direction of the gas-flame and made it hotter, for it is now burning a good deal more oxygen from the air. This is the cause of its change of colour. If you blow hard you will have a roaring, rough-edged, very hot flame, useful for heating a largish piece of work, but rather likely to melt any thin or projecting parts of it. If, however, you breathe gently through the pipe you will have a silent flame, with less ragged edges. This flame is not so fierce as the other, but it is hot enough to heat the work up sufficiently, and to melt the solder. Now turn the jet round till you have a flame only 4 inches high. Move the point of the blowpipe till it is only ⅛ or ¼ inch from the end of the horizontal tube. (It is cut off at an angle of 45°, but these measurements are taken from the top of the slope.) The character of the flame is changed again. You have a sharp spike of flame 3 or 4 inches long. And, if you look, you will notice that it consists of an outer, dark blue flame, with an inner, light blue one, extending about half the way along. Take the wig, Fig. 34, in your left hand and hold it beyond the end of the flame. Gradually bring it nearer. The fine iron wires of which it is composed will quickly become red, then white hot, and then burn—throwing out bright sparks in all directions. Move the wig away, and try again and again to see which part of the flame will make the wires begin to burn most quickly. You will find that the hottest part of the flame lies just beyond the tip of the inner, light blue cone. You have now learnt what you can do. You can heat the whole work up with the soft, gentle flame, and you can then, by shifting the position of the blowpipe, direct a sharp, very hot flame on to the solder and the parts near it. This is just what you should do in soldering. If you have

sufficiently warmed the whole work with the gentler flame, then immediately the hot, pointed flame touches the solder it will melt and run into the joint. With the large blowpipe and bellows you may get a similar variety of flames: the roaring, ragged flame for heating up and soldering large work; the quieter, gentler flame for smaller, more delicate work, parts of which might become melted in a fiercer flame; and the sharp, intensely hot flame which is so useful in actually melting the solder when the work has been sufficiently heated. You must practise with these different flames, so that you may produce each of them at will, and keep them entirely under control. Each type of flame may be produced however high or low the gas may be turned.

It is a good plan when annealing or soldering to move the work every now and then out of range of the flame, even for a fraction of a second. You can then see at once how it is getting on—if any part has become red-hot, or is in danger of becoming melted. When using the large blow-pipe, of course you move that instead of the work. If you have a difficulty in getting the work hot enough, probably more gas is required. But do not use a bigger flame than is necessary. For that is both wasteful and dangerous. You will find that the work will get hot quicker if you can hold it considerably below the jet and direct the flame nearly squarely on to it: while if the flame makes as it were a glancing blow at the work much of its heat is wasted. You will notice this particularly with the large blowpipe when you try to heat some piece of work which is nearly at the limit of the blowpipe's power. Indeed, in such a case it is well to build a temporary wall of coke, charcoal, firebrick, gas-carbon or any other not very fusible material behind the work to catch the flame when it has passed and to turn it back on to the work again.

It often happens that a room otherwise available for metal-working has no supply of gas. This need not, however, prove an insurmountable obstacle, for soldering lamps, burning spirit or oil may be used instead. Work as large as a fair-sized brooch can be soldered by means of the spirit

lamp shown in Fig. 13. Resting on a cast-iron foot is a large reservoir for methylated spirit. At a little distance is an inclined tube filled with cotton waste or wick, and connected by a tube with the reservoir. The inclined tube should be about ¾ or 1 inch in diameter. When the wick is lighted you have a very good flame. You can regulate it by pulling the wick up or down the tube. The flame is extinguished by dropping on to it the little disc of metal attached to the hinged curved wire shown above the reservoir. A cap is provided to cover the inclined tube and prevent the escape of the spirit when the lamp is not in use. The lamp is used in conjunction with the mouth blowpipe.

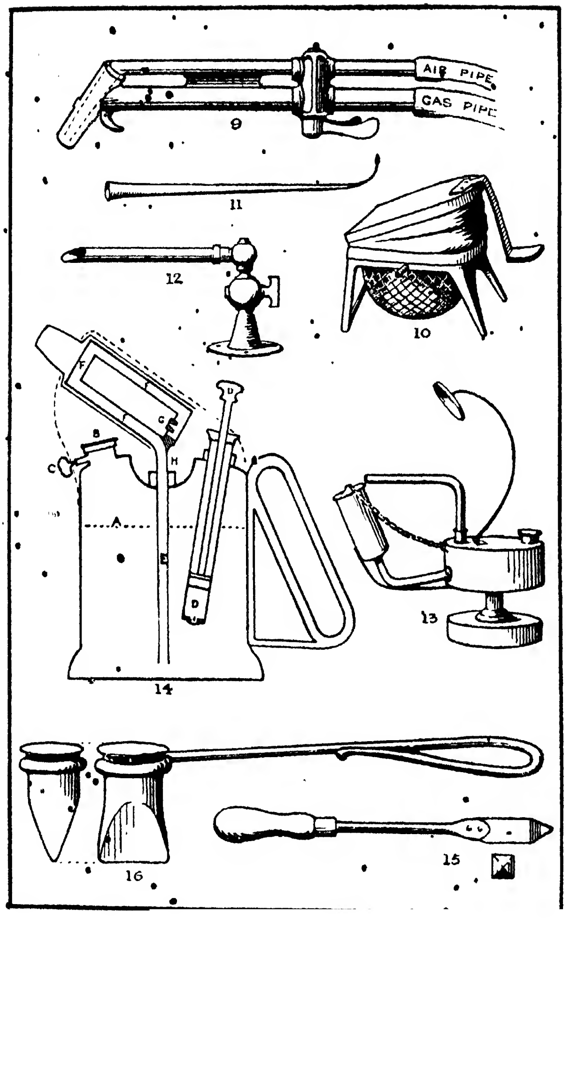
For larger work a lamp burning paraffin would be required. The Swedish blowlamps known as Ætnas are most useful. Of similar make are the Barthel brazing lamps, their principle of construction being similar to that of the lamps used by house decorators for burning paint off woodwork. The most useful size to buy holds about a quart of oil, and will burn for an hour with but little attention. It costs about 15*s*. The construction is shown in the Fig. 14. A is the reservoir, two-thirds full of paraffin oil, which has been poured in at the screw-cap B. C is a little air-tap. D the pump by which air is forced into the reservoir. E is the pipe for the oil, which runs from near the bottom of the reservoir through the tube F, and escapes by a minute hole at G. H is a shallow depression at the top of the reservoir. This little cup is filled with methylated spirit, which, when lighted, heats the tube F so much that any oil within it is turned to vapour. This gas, emerging from the pinhole G, burns with a hot blue flame, and rushes forward, keeping the tube F red-hot on its way. To start the lamp, open the air-valve C, fill the cup H with spirit and light it. When it has nearly all burnt away, but not before, close the tap C and pump some air into the reservoir. This air will, of course, collect at the top of the reservoir, above the oil. The pressure will force the oil to escape by the only way now open to it—up the pipe E, through the almost red-hot tube F,

where it will be turned to vapour, and out into the air at G, where it catches alight. It is well to pump as much air as possible into the reservoir, as this will send a good supply of oil to the vaporiser F. To extinguish the lamp it is only necessary to open the valve C. This relieves the pressure, and no more oil is forced up the tube E, so the lamp goes out at once. If you begin to pump air into the reservoir before the vaporiser is hot enough, you will drive through the jet G a stream of paraffin instead of gas. The remedy is: Open the valve, then heat the vaporiser more and start afresh. The lamp will burn upside down or in any position. But it sometimes happens, when the oil is nearly used up, that a sudden shake may put the flame out. Dense black fumes of paraffin vapour come from the jet instead. A match held near G may light the lamp again. But if the pressure is too great it may blow the match out instead. Therefore relieve the pressure a little by opening the valve C for a second or two. The jet will light up quite easily then. But at any time you can stop the lamp by opening the valve. So you will have no real difficulty with it. As a rule, as soon as the lamp is fairly alight, pump as hard as you possibly can. The lamp will then go for a quarter of an hour or more without any further attention. The flame from an Ætna lamp, quart size, is about 9 inches long, blue in colour and it roars considerably. When you have finished with the lamp always leave the valve open. If you do not, and the lamp is warm, oil will slowly rise in the tube E and flow out of the jet. Some of this oil will become burnt inside the vaporiser when next the lamp is lighted and clog the jet. Cleaning needles are provided with the lamps, and they should be used if ever the jet seems to have become at all clogged. Should you run out of methylated spirit, the lamp can be lighted, though it is not a good way, by holding the vaporiser, till hot, between the bars of an ordinary fire. Then close the valve and pump as usual.

It sometimes happens that a larger piece of work than the lamp can properly heat up, has to be soldered. The

simplest way to overcome the difficulty is to make up a good fire in an ordinary firegrate, and wait until it has burnt clear. Then make a hollow place near the centre and place your work in it. The heat of the fire should be sufficient to make the whole work red hot. And, if the flame from the blowlamp be brought to bear on it while yet in the fire, any part may be sufficiently heated to make the solder run.

The old method of soldering, employed before the introduction of coal-gas, was that in which a charcoal fire, excited by a blast from one or more pairs of bellows, was used. This was the method invariably employed until the middle of the nineteenth century, and in many places, notably the East, it is used to this day. Much of the most beautiful work in existence was executed by its aid. Charcoal may be purchased almost anywhere, or it can be made in small quantities as follows: Fill an iron box—an iron saucepan, for instance—with small logs of wood. Close it to exclude the air, and fasten the lid on with stout iron wire. But leave an opening for the escape of the gases. If the lid fits loosely it will do. Place the saucepan on a fire and leave it there until no more gas is driven off. Remove it from the fire and leave it till cold, and the charcoal will be found ready for use. Use a cast-iron saucepan, not a soldered one—for the latter would fall to pieces in the process. Then make a sheet-iron tray or hearth measuring about a foot across, with sides two inches high. It is well to make it work on a pivot, for it is a very great convenience to be able to turn work about while soldering. In the centre of the hearth is a small flat box of sheet iron, in the top of which a large number of small holes have been drilled. This box is connected by a pipe with the bellows. To make the hearth ready for soldering, place a red-hot coal on or near the perforated box, and heap the charcoal over it. Blow with the bellows, gently at first, but harder as the fire spreads, just as you have seen a blacksmith do. When a good fire has been obtained, level a space near the centre, and there place your work, piling up the hot charcoal all round. Work


AIR PIPE
GAS PIPE
9
11
12
10
F
G
B
C
H
D
A
E
D
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16
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the bellows till you see the solder flow, then cease blowing and move some of the charcoal away, so that the work may cool down. The old workers used to have, for small work, a thin iron bowl with many holes punched through it from the inside. This bowl they placed over their work, and heaped the charcoal right over both. They would leave one of the punched holes uncovered, so that they could look in from time to time to see how the work was getting on. The holes in the bowl were punched from the inside with a sharp spike. This left ragged edges on the outside of each hole, which kept small pieces of charcoal from falling in.

A furnace which will require no bellows can be made in the following way. Take some clay and beat it up well with a little sand. With this, or with bricks, build a circular furnace about a foot in diameter inside, with walls four inches thick. Leave a hole four inches square at one side near the ground. Just above this put an iron grating all over the floor of the furnace. The air will then be able to enter at the square hole and pass through the grating. Build the walls straight up for about a foot above the grating. Then arch them over the top, leaving room for a piece of three-inch iron piping for a chimney. This should run into an ordinary house chimney. Leave an opening at one side, six inches square, for a door, and close it with a piece of firebrick. Make two or three peep-holes through the side of the furnace, closing them with pieces of mica. Put a thick layer of charcoal over the grating, and light it by putting some red-hot coals among it. Then close the door. You will get a good draught, and can regulate the heat by varying the size of the opening under the grating. The amount of heat produced varies with the wood from which the charcoal was made. That made from birch is said to give the highest temperature. When the furnace is hot the work to be soldered, resting on a piece of thin sheet iron or a piece of fireclay, is placed on the hot charcoal and the door closed again. It is necessary to watch the work all the while through the mica window. Immediately the solder flows

open the door. This, by stopping most of the draught through the charcoal, will prevent the heat from rising higher. Remove the work at once with a pair of long-handled tongs. A furnace very similar to this was very widely used in olden times, though bellows instead of the long chimney were often employed in conjunction with it. It was also used for enamelling. The grate under the ordinary scullery boiler or copper is arranged in a very similar manner.

It is well to remember that the fumes given off by hot charcoal are injurious, so they should be led into a chimney or into the open air.

CHAPTER V

SOLDERING (*continued*)

Soft solder—Composition of soft solders—Fluxes—Soldering bits—Various hints—Removal of soft solder.

We now come to the soft solders. They melt at a comparatively low temperature, so they may be used for soldering almost any metal or alloy. Soft solders consist chiefly of tin and lead, though other metals are sometimes added to lower the melting point. Mixtures of tin and lead melt at a temperature lower than the melting points of either tin or lead. So an alloy, that is to say, a mixture of tin and lead may be used as a solder for either of those metals. It has been found that an alloy containing two parts of tin to one of lead, or, more precisely, 63% of tin to 37% of lead has a lower melting point than alloys made in any other proportion. It fuses at 175° C. It is also nearly the hardest of all the lead-tin alloys. As the two qualities most desirable in a soft solder are (1) low melting point, and (2) strength, this alloy forms one of the best soft solders known.

There is another alloy of tin and lead much used by plumbers. They employ it for "wiping" joints in lead pipes. It consists of two parts lead to one of tin. Its fusing point is about 250° C. This alloy undergoes a prolonged pasty stage on cooling, and it is on this property that the plumber depends. For, as pointed out by by Mr. Hiorns, at temperatures above 180° C. the mass consists of granules of solid metallic lead, floating in a liquid which is almost identical with the soft solder mentioned above. The mass continues in a pasty state until it has cooled down to about 180° C. The above two are the soft solders in

general use, but occasionally one is required with a much lower melting point. For this purpose bismuth, cadmium or mercury is added to the alloy of tin and lead. Thus, an alloy composed of two parts bismuth and one part each of lead and tin, will melt in boiling water. For further particulars of these fusible alloys see Chapter XXVI.

In making soft solder it is well to use a deep, narrow vessel, rather than a shallow, wide one, for these alloys oxidise rapidly when heated and exposed to the air. A layer of dross forms on the surface. It is usual, therefore, to put a little fat or resin on the surface of the molten metal to protect it from the action of the oxygen in the air. The metal should be thoroughly stirred with a stick of green wood before pouring. The gases liberated by the charring of the wood assist in bringing the dross to the surface. This should be skimmed off and the metal poured at once. A good mould can be formed from a piece of angle iron, propped up level on the floor. It will form a long, narrow trough, the ends of which can be stopped with a little heap of sand or clay. Pour the solder into the trough to a depth of about ¼ inch, starting at one end of the trough and moving towards the other. When cool the solder will be in a long triangular stick ready for use.

As a comparatively low temperature is sufficient to melt soft solder, all that it is necessary to do is to apply the heat so that the parts of the work near the joint to be soldered may be made hot. The solder will flow before the heat has had time to spread. The tools required for soft soldering are few and inexpensive; a soldering bit (or other heating apparatus), some acid and some pieces of solder and zinc, are the only essential ones. The flux employed may be chloride of zinc prepared in the manner described below, sal-ammoniac, resin, or even tallow. Its purpose is to keep the air away from the joint while it is getting hot, and to assist the flow of the solder. For iron or steel, resin or sal-ammoniac is used as a flux. But for copper and its alloys chloride of zinc is generally employed.

To make this flux, take 8 oz. of hydrochloric acid (known also as muriatic acid or spirits of salt), and put it in a strong dish in the open air. Add to it pieces of clean zinc cut small. The acid will boil violently, getting quite hot, splashing all around and giving off poisonous fumes. Do not, therefore, add too much zinc at a time, or the acid may get hot enough to crack the dish. Go on adding zinc till no more gas is given off. The acid now is said to be "killed." When quite quiet the liquid, which is now zinc chloride, is ready for use as a flux. Pour the clear liquid into a bottle. You can use a stick, a brush or a chicken's feather to apply it to the joint. A flux for soft soldering can be made in the form of paste in the following manner. Take some petroleum residue, such as vaseline or petrolatum. (These are identical in composition, but the latter is cheaper.) To one pound of this add one ounce of chloride of zinc, prepared as described above. Mix well, and the flux is ready for use. Prepared in this way it has the advantage of not spattering. Chloride of zinc should always have some excess of zinc, for any free acid might corrode the work if left on it after soldering. Powdered sal-ammoniac, mixed into a paste with water, also works excellently. A flux which may be used on any metal, except aluminium, is made of the following ingredients: ½ pint spirits of salt, zinc enough to kill it, ¼ oz. sal-ammoniac and 2 oz. water. Powdered resin or resin and sweet oil are largely used by plumbers as a flux for making joints in lead pipes.

The soldering bit, Fig. 15, has a copper head and an iron shank. The head is formed from a bar of copper, either pointed or flattened out to a chisel shape. The shape shown in Fig. 16, with the head fixed at right angles to the shank, is a most convenient form. In buying or making a soldering bit be sure that the copper head is not less than a pound in weight. Smaller ones do not hold sufficient heat to warm up any but the smallest pieces of work. Before using the bit its edge must be "tinned," that is to say, coated with a thin layer of solder.

To do this, heat the bit in the flame of a gas-ring or in a red fire—not a smoky one, for that would make it dirty and unusable. It must not be allowed to get red hot, though. It should feel nice and warm when held four inches from the cheek. Put a small piece of soft solder and a lump of sal-ammoniac on a piece cut from a tin canister. By the way, a tin canister is made of thin sheet iron with a coating of tin on each side. Rub the soldering bit on the tin. Some of the solder will melt and stick on to the bit wherever the sal-ammoniac also touches it. Rub the bit about till a coating of solder is spread all over its working edge—the part farthest from the handle. The bit is now ready for use. It is not, however, an essential tool, for the blowpipe can be, and frequently is, employed to melt the solder.

The work must first be prepared by scraping the parts to be joined quite bright and clean; any loose pieces being tied into their places, if necessary, with wire. Put some flux along the joints. Heat the bit, then holding it in the right hand rub the edge on the piece of tin canister before mentioned. Then take a stick of solder in the left hand and dip the end of it into the flux. Slide that end up against the edge of the bit. In a second some of the solder will melt and hold to the bit. At once rest the bit against the joint, taking care that the metal on both sides gets equally heated. The solder will run off the bit into the joint as soon as the work is hot enough. If it does not flow easily, reheat the bit and add more flux to the joint. Any pieces of solder which fall on the bench should be picked up by touching them with the hot bit. The solder turns dull as it sets, therefore the work should not be moved till this change has taken place, or the liquid solder may run out. When all the joint is soldered, reheat the bit and run it along the joint as quickly as possible while melting the solder. This is to spread the solder quite evenly along. It will be much easier to scrape off any superfluous solder now than if it had been left in uneven patches.

To soft-solder flat surfaces together. Clean them very thoroughly, apply flux, then lay a sheet of tinfoil between them. Tie together in place and heat until the solder (tinfoil) runs. The metal lining of tea-chests makes a good soft solder. In joining together pieces of pewter or tin it is possible to do without solder altogether, or rather to use some of the metal itself as solder. The bit should be used while very hot and the work done quickly. For if the tool were allowed to rest for more than a second or so a hole might be burnt right through the metal. Should such an accident occur, the hole, if large, may be plugged with fresh metal, and the joint soldered up while the plug is held in place by a pad of cloth or a piece of wood. Flux must be applied just as though solder were being used. Any superfluous metal can be filed or scraped off afterwards. In making lead tanks for some purposes, where chemical action might be set up between the lead and any solder used, all the joints are made or "burnt" in this way. The work is done with a blowpipe, and a strip of clean lead is held against the joint in such a manner that it fuses together with the edges of the work.

Soft solder, if heated to much above its ordinary melting point, when in contact with any gold, silver, copper or brass object, will penetrate deeply into the metal of which it is composed. It forms a dark, spongy alloy with the gold, silver or copper, as the case may be, which can be got rid of only by cutting the whole affected piece out. It will be clear then that no hard soldering can be done on any piece of work on which there is any soft solder whatever. You must either remove every trace of it first, or abandon your intention of using hard solder.

Soft solder may be removed by boiling the article upon which it is in a solution made as follows. Take—

Green copperas	2 oz.
Saltpetre	1 oz.
Water	10 oz.

Powder the first two, and boil them in the water in a cast-iron saucepan. When cool, the solution will crystallise. If it refuses to do so completely, reheat the liquid which remains. When all has crystallised, dissolve the crystals in hydrochloric acid in the proportion of 8 oz. of acid to 1 oz. of the crystals. Dilute this liquid in four times its weight of boiling water when required. Boil the articles in this diluted solution. Another method of removing soft solder is given on page 66.

CHAPTER VI

FILIGREE AND OTHER SMALL WORK

Wiredrawing—Tube or "chenier"—Tools—Jeweller's bench.

QUITE a number of tools are required for this work, though most of them are not very expensive. Drawplates, pliers and soldering materials are perhaps the most important, so we will discuss these first. The usual form for a drawplate is that of a piece of steel several inches long, one to two inches wide, and perhaps a quarter of an inch thick. The steel plate is pierced by several rows of holes. Drawplates are made with holes of various shapes—round, square, oblong, triangular, half-round, star and so on. The holes vary in size in regular order, the largest on a plate measuring perhaps $\frac{3}{16}$ inch in diameter, the next a very little less and the twentieth or thirtieth hole perhaps $\frac{1}{16}$ inch. On another plate the series of holes may commence at about [illegible] inch and go down to $\frac{1}{32}$ inch. On another the smallest holes may be so fine as to be almost invisible at their smaller end. All these holes are widened out considerably towards one side of the plate. In the construction of these drawplates the holes are drilled first, and widened out at one end. Then a long tapering mandrel of the required section (round for round holes, square for square ones, etc.), is driven into each hole in succession, but to a different depth in each, with the result that each hole tapers slightly, and is a little larger or smaller than its nextdoor neighbour. After the holes have been thus gradated the plate is trued up, hardened and tempered. The drawplate is used in reducing wire to a smaller diameter, or in altering its section—changing a round wire into a (smaller) square one, for example. Suppose that you have a piece of round copper wire $\frac{1}{16}$ inch in

diameter which you wish to reduce to $\frac{1}{32}$ inch. At one end file a point about an inch long. For gold or silver wire you would not file the point, but produce it by hammering. Then anneal the wire as described below. Put the draw-plate in the vice with the smaller end of its holes towards you. Or place it between cleats screwed to the bench.

Wire measuring up to $\frac{1}{8}$ inch may be "pulled down" by hand, but for larger sizes a drawbench is necessary. A description of this tool is given on page 138. Take the wire in your left hand with its pointed end towards you, and hold a pair of drawtongs, Fig. 17, or large pliers in your right. The end of one handle of the drawtongs is bent round to give a better grip. Try the wire through various holes in the plate, putting the point into one after the other from the far side, till you find a hole through which the wire (and not only the point) will just pass. Put the wire into the next smaller hole, and the point will come some distance through it, and will then jam. Seize the projecting point and firmly pull the whole length of the wire through the hole. If the length is considerable you may, after the first yard or two, hitch the wire round your body and pull without the aid of the drawtongs. The wire, by its forcible passage through the tapering hole in the plate will have become smaller in diameter, longer and slightly harder. Pull it through the other holes in succession until you have reduced it to the required size. It is usual to oil or grease the wire, or the holes in the plate, to reduce the labour. Oil, tallow, vaseline, or even soap, may be used. Grease from a paraffin-wax candle acts well. Olive-oil soap is used by some professional wire-drawers. Is a good plan to wrap a rag, soaked in the lubricant, round the wire at the far side of the drawplate, when long lengths of wire have to be drawn down.

When the wire has passed through a number of holes it will feel hard and springy. If you do not anneal it it may break. Wind it into a close coil, as small as it will conveniently go to. For small sizes, perhaps an inch or two in diameter; for thicker wire six inches, more or less. With thin wire be sure

that no ends or bows are allowed to project, for they would almost certainly be melted in the annealing, so bind the coil with fine binding wire, if necessary, to prevent this. Then place it on the wig or charcoal and gently warm it with the blowpipe until it reaches a dull red heat. It is not necessary that it should be red hot all round the coil at the same time, but you must make sure that every part of the wire has been made red hot once. Use the soft, more gentle flame for this work, not the roaring or the pointed flame, page 28. Small wire can be made into a coil, bound with binding wire, and annealed by hanging the coil on the end of the jeweller's blowpipe and swinging it round and round over the jet until it is hot enough. Cool the wire in water,—not pickle, and remove the binding wire. If you put silver and iron in contact, into any sulphuric acid pickle which has been in contact with copper, or into fresh pickle in a copper pan, a thin film of copper will be deposited on the silver, and it may cause trouble. The wire is now annealed, and all the springiness has gone out of it. In reducing large wire to small it may be necessary to anneal it several times,—whenever it gets hard in fact. Wire-drawing is not a difficult task, but it is well to buy wire as near as possible to the size you require, and so save the labour of drawing it down.

When a comparatively small amount of wire is required it can be made from scraps of metal in the following manner. Take an ingot mould of suitable form, that is to say, one with a long narrow recess tapering to a point at the end opposite the pour, Fig. 7. Melt up the scraps in a hollow in the charcoal and tilt the molten metal into the mould, see page 11. Larger pieces may be obtained by cutting a strip from the edge of a thick sheet of metal. But in either case take great care to remove all projecting edges or loose pieces from the ingot or strip before you draw it down. You must at any cost avoid longitudinal folds or pleats, for they would produce cracks running down the wire. So, by means of hammer, file or scraper, true up your ingot that no cracking or scaling can take place. Also examine the wire from time to time

while you are drawing it down. To draw wire which is not circular in section requires a little more care. In making square wire, for example, there is some risk in the earlier stages—before the corners have become sufficiently developed—that the wire may become twisted in its passage through the plate, with the result that the corners are damaged, or the wire broken. To avoid this, feed the wire into the hole quite truly, holding it with pliers if necessary. Another plan is to allow it to pass between the jaws of a wooden clamp, or between two boards screwed closely together, before it reaches the drawplate. But you must avoid any twisting.

Wire oblong in section can be made from square wire, either by flattening it with the hammer or by passing it through the rolls. The rolls, or flatting mills, are a pair of hardened steel rollers, worked by a wheel or handle, and adjusted by screws. Sheet metal or wire may be reduced to any thickness by flattening it between the rollers. Oblong wire of any size can be produced in this way by using wire of suitable size to commence with. This is a convenience, for drawplates do not always give the exact shape you require. In feeding wire through the rolls to flatten it, take care that it goes through exactly the same place between the rolls, all the while. For if you allow it to creep from side to side it will come out the other side irregular in width. Try it and you will see why.

Half round wire may be produced with the aid of a round hole drawplate. To do this, take a piece of wire and slightly flatten it, either with the hammer or by passing it through the rolls. Fold the flattened wire in half. Make the point at the double end, soldering the two strips together for a short distance if they seem inclined to separate. Anneal the whole length of the strips. Then pull them through the round holes in the ordinary way. Take care that the two pieces do not get twisted as they go through the holes. Keep them true by holding the blade of a knife between them, close up to the drawplate. Of course, two lengths

of half-round wire are produced instead of one piece of round wire. In the same way oblong wire, with the section of half a square, may be produced with the square-holed drawplate, but be careful that it does not wind.

Hollow wire or tube can be made from strips of sheet metal. To make a tube ⅛ inch diameter take a strip about ⅜ inch wide. Mark off the strip from the edge of the sheet of metal with the dividers, holding that tool so that one leg runs along the bench against the metal while the other scratches the line on its surface, Fig. 18. This plan must, however, be followed only if the edge of the metal is true. Cut the strip off and see that its edges are true and parallel. Make a point at one end by cutting a small piece off each side of the strip, Fig. 19. Now take a piece of hard wood in which a number of grooves of different sizes, semicircular in section, have been cut; or a metal swage of the same form, Fig. 20. See that the sharp top edges of the grooves are rounded off. With a narrow hammer, Fig. 21 for example, tap the strip into the groove, commencing near the edges. Or you may hold a mandrel (a length of round steel wire) in line with the centre of the strip and drive both into the swage with a hammer which has a slightly convex face, see Figs. 22 to 24. It is most important that the metal near the edges of the strip shall be curved well, otherwise the sides of the tube may work thin near the joint. Turn the strip a little in the groove, and by carefully placed blows tap the metal still further round the wire. It is indeed possible to close the metal completely round, so as to form a tube. Should you do this, however, it is well to take the precautions of slightly oiling the wire to facilitate its withdrawal, completely closing the tube for a few inches only at a time, and gradually withdrawing the wire from the completed end of the tube.

To proceed with our tube drawing, however. After the strip has been tapped round a certain distance in the swage the process may be completed by drawing the strip through the drawplate just as though it were wire. But

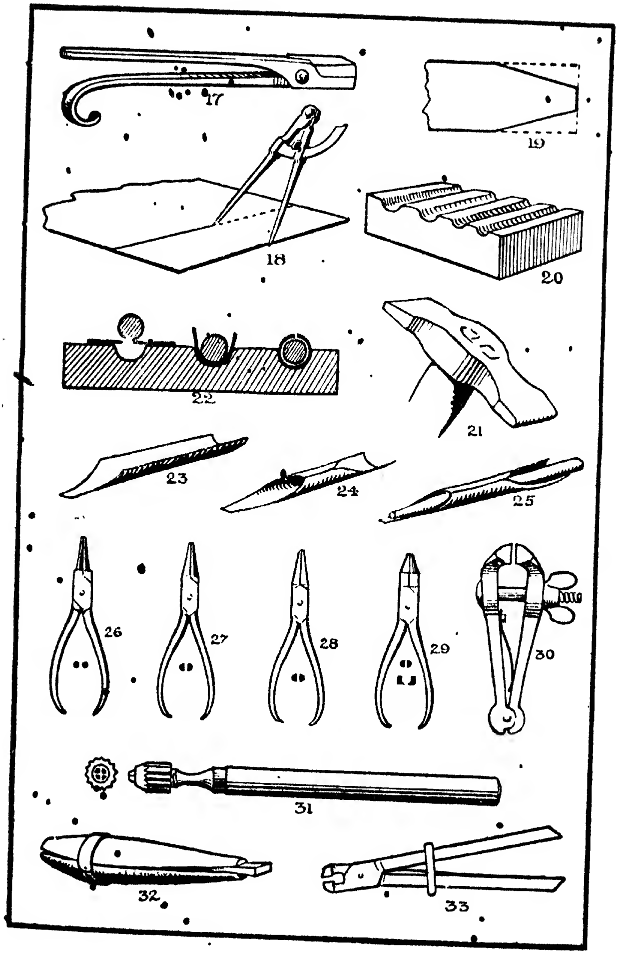
to keep the opening in the tube to the same side (it might otherwise wander round spirally) hold the blade of a knife firmly in the gap just as it passes through the drawplate; or, if the join has already got twisted round, hold it true with pliers as it goes through. If you wish the tube to be true inside, first file a point on the mandrel or wire, then rub oil or wax over both mandrel and strip before you close the metal round. But do not withdraw the mandrel in this case; leave it with its tapering point level with the point you have cut at the end of the tube. The mandrel must be longer than the strip of metal (tube). Put them both through the drawplate together until the outside of the tube has been drawn quite true and it has been reduced to the desired size. Fig. 25 shows the tube before it is completely closed round the wire. To remove the wire push the end of it which projects from the tube through the small end of a hole in the drawplate which just fits it. Then draw it out. It is well to use a copper, rather than a steel, wire for this operation, for steel is practically incompressible, and you may unduly thin the metal of which the tube is formed. Anneal the tube with the copper wire inside it and drop it into oil before you attempt to separate it from its mandrel. The tube may be soldered up the side now if necessary. Hollow half-round wire can be made from strip. It should be first swaged nearly to shape and then put through a drawplate which has half-round holes, a pointed burnisher of suitable size being held in the hole in the drawplate against the strip. Hollow wire of almost any section can be made from tube or strip metal in one or other of the ways described above. Another kind of drawplate, not very frequently met with, is the ruby plate. It is used for extremely fine wire. As its name implies, the hole for the wire is pierced through a ruby.

To straighten a length of wire first anneal it, and then stretch it tightly. If this is not sufficient, rub it, while tightly stretched, over the corner of the bench pin; this should

take out any kinks. Another plan is to put a number of stout wire nails in a row in the bench, and to bend the wire in a zigzag fashion to the left of one nail, to the right of the next, to the left of the third and so on. Then to pull the whole length of wire through the nails. The zigzag bending which it gets when passing the nails pulls the wire quite straight.

After drawplates, pliers are the next essential tools for filigree work. Of these you will require several pairs. Round-nosed pliers, Fig. 26, one pair quite small and one a larger size. Snipe-nosed pliers, Fig. 27, two pairs, four inch. Flat pliers, Fig. 28, one pair. Tapered bell pliers, Fig. 29, one pair. A hand-vice, Fig. 30. A pair of slide tongs, Fig. 33. Beech or boxwood clams, Fig. 32. A holdall, or universal holder, Fig. 31, this is a four-jaw chuck fitted with a handle. It is useful for holding mandrels, wire, files, etc. Get all these tools of good quality. As the jaws of cheap pliers either break or bend apart, so that you get no grip, avoid them. The inside surface of the jaws of pliers is scored to keep work from slipping. But the roughening may be such that the work would be badly scratched. It is well to smooth down the extreme roughness, by rubbing the jaws on fine emery paper until they can grip well without damaging the work. Do not make them too smooth, though. To hold work firmly with ordinary pliers requires considerable effort. If, however, you take any ordinary flat-nosed pliers and cut the jaws down to, say, one third of their ordinary length you will find that the strength of their grip is tremendously increased. This is a way to find a use for broken-jawed pliers.

Materials for soldering come next. First the jeweller's jet and mouth blowpipe. These are the tools generally used, though a few jewellers prefer to have a small hand blowpipe with bellows. If gas is not available the spirit lamp may be used instead. Jeweller's wig, Fig. 34. Charcoal. Some small pieces of thin sheet iron. A little plaster of Paris. Borax, slate and brush. Tweezers for picking up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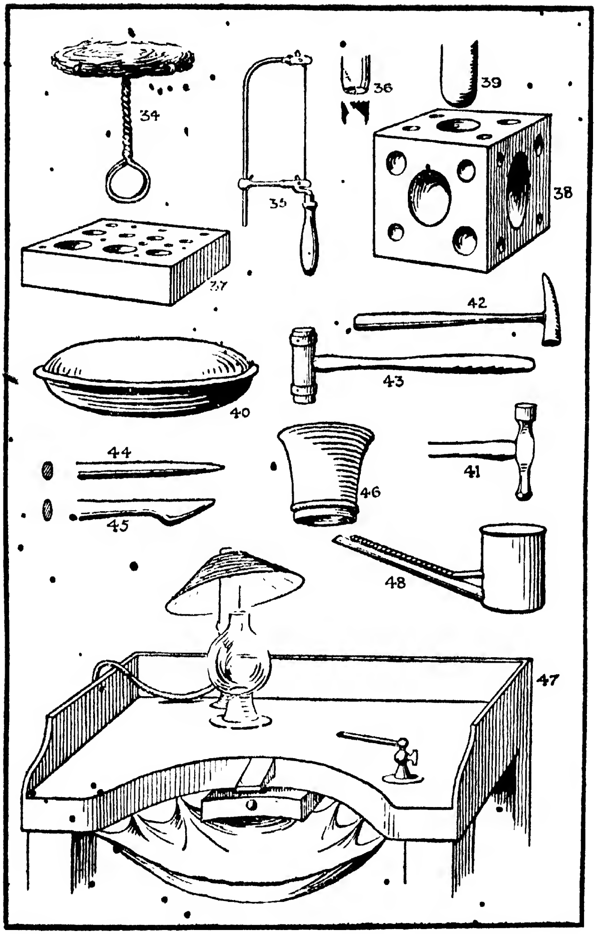
pieces of solder, or parts of the work. It is well to have a pair of these of brass, for they can be used for lifting small articles into or out of pickle. Steel tweezers are not suited for this work. A very efficient pair of brass tweezers can be made from a strip of hard sheet metal, 7 inches long by $\frac{3}{8}$ inch wide, size 10 on the metal gauge. The strip has only to be folded in half, hammered a little, and the loose ends cut and filed to a point. Binding wire; this is best charcoal iron wire. The small sizes required can be obtained in $\frac{1}{4}$-lb. reels. Get Imperial Standard Wire Gauge Nos. 28 and 32. A little sulphuric acid (vitriol) for making pickle. A small copper boiling out pan. For gold you use nitric acid pickle in a porcelain pan. The use of these pickles is explained on p. 24.

You will also require :—(1) Needle files. These are slender files, 5 or 6 inches long. They are made in a number of shapes. Flat—one narrow side is sometimes left smooth or "safe". Rat-tail—these are circular in section. Half-round—flat on one side and convex on the other. Fish-belly—convex on both sides. Knife-edge—triangular with one narrow and two wide sides. Donkey-back—triangular, with one cutting and two smooth sides. Square. Three-square—in section an equilateral triangle. (2) A small, very sharp chisel for cutting filigree wires. Wires have often to be cut through at, say, an acute angle. To file them thus would be wasteful. But if you rest the part to be cut on a piece of brass or bronze (a worn halfpenny will do,) you may cut it cleanly with the chisel. (3) A pair of straight snips or nail scissors. Japanese filigree workers fasten a loop to the handle of these, through which they slip finger or thumb. The tool is therefore kept on, if not in, the hand all the while. (4) Some scorpers. Get a few of these, flat and round, $\frac{1}{16}$ inch across the face, and one knife-edged. (5) Piercing-saw frame, Fig. 35, 3 or 4 inch. (6) Saws, No. 00. The easiest way to put a saw in is to fasten it first in the top jaw—that farthest from the handle. When necessary, thread the saw next through the hole prepared for it in your work. Then

press the top jaw firmly against the bench, so as to shorten
e span for the blade. While the frame is thus com-
sed, fasten the loose end of the blade in the lower jaw.
n the pressure is removed the saw will be stretched
ly. The teeth should point towards the handle, so
the saw cuts when it is pulled, not like a carpenter's saw—when pushed. (7) Drillstock and drills. The former is more useful if fitted with a universal chuck. (8) Cutting punches, Fig. 36. These are steel punches with a sharp, circular edge. They are for cutting out small discs from sheet metal. Be careful in using them not to let the sharp edge of the punch come in contact with a steel stake. Always put a piece of brass between the metal from which you cut the discs and the steel stake upon which you cut them. Give the punch a smart blow at first. Then if the metal is not quite cut through, hold the punch firmly in the circular mark already made and give it a few lighter taps, rocking the tool gently from side to side as you do so. It gets through easier so. A cake of lead or zinc is often used instead of the steel stake for cutting discs upon. Of course no brass is required in this case. The discs when cut will be slightly convex, but to boss them up more a doming block, Figs. 37 and 38, and set of doming punches are useful. (9) The doming block is a square or oblong piece of brass or steel in which is cut a series of hemispherical hollows. These cup-shaped recesses vary in size from 1½ inch to $\frac{1}{32}$ inch. The doming punches, Fig. 39, fit the hollows. To produce a rounded boss or half-bead from a disc of metal drop it into a hollow which is rather larger in diameter. Set the disc level in the recess. Take a suitable punch and place it quite centrally on the disc. Give it a good blow with a hammer, and the metal will be driven into the hollow. If necessary it may now be shifted to a smaller hollow, and made into a complete half-ball by using the punch which corresponds with the hollow. You may even file off any metal which projects above the block before you remove the half-bead. You can make a half-bead of any given

size by taking a disc of metal one third larger in diameter. If the metal gets hard, anneal it. If you wish to dome up a disc only slightly you have but to drop it into a hollow of considerably larger diameter, and use a large punch. A doming block is not, however, an essential tool. Suitable hollows may be hammered in a cake of lead, tin or zinc or any other material which is hard and tough enough for the purpose. It is well, however, to put a sheet of thin paper between the disc and the block to prevent the transference of any trace of tin or lead or zinc, as the case may be, to the boss. (10) A sandbag, Fig. 40. (11) Triblets. These are tapering rods or mandrels, generally of steel. They are used for "setting" rings or collets true, or for enlarging them after they have been soldered. To do this, you slide the ring on to the triblet as far as it will go. Holding the large end in your hand, rest the narrow end of the triblet upon the bench, so that the ring is pressed against its front edge. Tap the the ring gently with the mallet; turning the triblet all the while. Keep the triblet pressed as far through the ring as it is able to go. When the ring fits the triblet it is quite circular, though it may yet require flattening as described below. If, however, you wish to enlarge the collet, use a steel hammer. This will stretch the metal quickly. Take care though that your blows are placed regularly, and that you stretch both edges of the collet equally. If on account of the hammering one side of the band grows convex as it rests on the triblet, you must hammer on the middle and the concave side to bring it true again. Triblets are made in various sizes. An old cotton spindle makes a very good small one, for it tapers from about $\frac{1}{8}$ to over $\frac{1}{4}$ inch in diameter. Oval, oblong or square triblets are also used. You should have others which go up to $\frac{1}{2}$ or $\frac{3}{4}$ inch in diameter. For sizes larger than this it is usual to true up a ring on the bickiron or sparrowhawk. The arms of these tools are not always truly circular. But you slide the ring along the arm as far as it will go, and turn the ring while tapping it, instead of the stake as before. When a ring has been trued up on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the triblet or bickiron it will be circular, but it may not be quite flat. So a flat stake (12) will be required. This is a piece of steel 3 or 4 inches square, perhaps an inch thick, and quite smooth and true on top. The domestic flat-iron makes a very good substitute. Blocks of wood should be fastened each side of the handle so that it will stand firmly face upwards. (13) The jeweller's hammer, Fig. 41, has one flat and one rounded face. It weighs only a few ounces. To flatten work without marking it in any way a horn mallet, Fig. 42, or a fibre-faced hammer, Fig. 43, should be used. The mallet is much the lighter tool of the two. (14) A steel burnisher or two, Figs. 44 and 45. (15) A jeweller's eyeglass, Fig. 46. If you take a length of piano wire, form a loop at one end for the glass, and bend the remainder into a curve to fit round the back of the head, the glass may be kept in position without effort. (16) The jeweller's bench, Fig. 47, has a large semicircular piece sawn out of the top in front. From the centre of this curved recess a piece of wood projects. It is known as the "pin." It is a piece of hard wood, perhaps 4 inches long, with a sloping top, and it is let into the front edge of the bench. Work is held on or against it while it is being filed or otherwise proceeded with. To catch the filings a large piece of sheepskin is fastened under the top of the bench. It extends below the pin, across the recessed front of the bench from arm to arm. The soldering jet is fastened on the right hand arm, near the extremity. The gas burner or lamp is right in front of the worker. A large globe filled with water, standing on the bench, throws a concentrated spot of light on the pin, so that the work is always well illuminated.

CHAPTER VII

FILIGREE (*continued*)

Grains—Bosses—Rings—Leaves—Filigree wire—Soldering—Boiling out—Filed solder.

THE principal "motifs" used in filigree and other jewellery, besides representations of the human figure or animals are (1) Jewels and their settings; (2) Architectural forms, ships, crowns, crosses, shields and other symbolic or heraldic devices; (3) The leaves, fruit and stalks of plants; (4) Wires—plain, twisted or plaited; (5) Rings; (6) Bosses and grains.

We will take grains, the simplest form, first. They have considerable decorative value, especially if they are arranged in groups. Mr. R. L. B. Rathbone in his valuable book on *Simple Jewellery* illustrates many beautiful arrangements. Grains also have an important constructional value, for when soldered close up to the point of contact of two other forms, the grain strengthens the joint considerably.

If you put a tiny fragment of silver or gold on the charcoal, and allow the tip of the bright blue flame from the blowpipe to touch it, it will melt instantly, and run up into a ball, or "grain." This little bead of metal will be slightly flattened where it rested on the charcoal when cooling. If you wish to make truly spherical grains, and it is worth while so doing, first make a number of little pits in the surface of the charcoal block. These pits can be made by pressing the head of a round-ended repoussé tool of the correct size into the charcoal. The pits should be about the size to take the lower half of the grain. Then lay the piece of metal which is to form the grain just over the hollow. When the metal melts it will form a practically perfect sphere and it will not

run about, as a grain formed on a flat surface will. With a little practice you can make grains pretty quickly in this manner. But if you wish to produce hundreds or thousands of them there is another, much quicker method. Take some fine wire and make from it, in the manner described below, a sufficient number of little wire rings, all of the same size. Now these rings being all of the same diameter and from the same wire must have exactly the same amount of metal in each. Therefore when melted they will form grains of equal size. Take a little box made of sheet iron. Put a layer of powdered charcoal over the bottom of it. Then arrange rows of the little rings, side by side, but not touching each other. When the floor of the box is covered shake over the rings another layer of powdered charcoal. On that arrange another series of little rings. Go on with these alternate layers of charcoal and rings until the box is filled. Tie the lid on with stout iron wire, and put the box in the fire. Let it get bright red hot. Then take it out and cool it in water. Wash the charcoal away. You will find that all the rings have changed into grains. When you have made the grains it is well to boil them in pickle to clean them, then to wash them in water to get rid of any traces of the acid, and afterwards to keep them in a little tin box for safety.

Grains can be made $\frac{1}{8}$ inch in diameter or larger, but when big they use up so much material that it is better to make hollow bosses instead. Little discs of metal may be formed from grains by flattening them on a stake with the hammer. If the grains should show signs of cracking round the edges before they are sufficiently flattened for your purpose, they must be annealed. Then you may proceed with the hammering. Flat discs form a valuable contrast to more rounded forms in a design. But should you wish to do so you can boss them up in the doming block, or even in the lead cake. But to boss up flattened grains is to go a long way round, for if you have a set of cutting punches (see Fig. 36), you can cut the discs from sheet metal. If you have not got the punches you can cut the discs out with shears, and file them

up truly. It is not always necessary to raise bosses very high. A slight convexity is often sufficient to catch the light. Concave discs also make an effective contrast with the wirework among which they are placed.

Rings of wire have many uses. They are both decorative in themselves and valuable as a means of linking up different parts of the work. The rings can be made from wire of any section, plain or twisted. And the links themselves may be of round, oval, square, oblong, diamond, hexagonal, or almost any other plan. The usual way to make them is to take a mandrel, a piece of wire or tube, the section of which is that of the opening through the rings required. Thus, you wish to make a number of rings, oval in section, measuring $\frac{1}{8}$ by $\frac{3}{32}$ inch inside. Take a piece of steel, iron or brass wire of the required section, cut a strip of thin paper, $\frac{1}{2}$ inch wide, and paste or gum one side of it. Wind this paper spirally round the wire, taking care not to allow any overlapping. Next take some of the wire you are to use and, after seeing that it has been annealed, grip one end of it against the paper-covered mandrel with the hand-vice, slide-tongs or any other convenient tool. Then wind the wire closely and evenly upon the mandrel, turning the latter with the right hand, and keeping the wire tightly strained with the left. The wire should be wound quite straight round, not diagonally across, the mandrel. If the coils take this diagonal direction they will turn out larger than you wished. Wind as many coils on the mandrel as you wish to make rings. Then anneal the coiled wire while it is on the mandrel. The strip of paper will be burnt away in the process and the wire may be afterwards slipped off the mandrel without any trouble. It is not necessary to use the paper strip when winding small circular rings—they will generally slide off easily enough if you have not a very long coil. But with other shapes the wire is found to grip the corners of the mandrel so tightly that the coils can only be withdrawn from it with difficulty. So use the paper except for circular rings.

You have now a close spiral of wire. To cut it into

rings, you can either grip the coil in the clams, gently, not to crush it; or hold it in the hand-vice, first putting in a piece of leather to protect the coil from the roughness of the jaws, and then cut through one side of each coil with the piercing-saw. It is well to use a fine saw, 00. The rings, as they are cut through, may drop out of the clams. They are safer so, for they might otherwise get in the way of the saw. A quicker way of cutting off the rings is that of using the snips or scissors. It is only necessary to watch that you cut straight up the coil,—you might otherwise get more or less than a complete ring. The extremities of rings which have been cut with the snips do not come together quite so neatly as those of rings which have been cut with the saw. But if you are making the rings only to melt them into grains this will not matter. There is yet another way of cutting the rings from the coil. Take a piece of steel wire, the size of the mandrel upon which you wound the wire. Insert at one end a small piece of clockspring, leaving part of it, sharpened to a knife edge, projecting on one side. Slide the coiled wire down until its last turn rests against this spur. Put the other end of the iron wire through the small end of a hole in the drawplate, which will just admit it. One end of the coiled wire therefore rests against the drawplate, and the other against the sharp spur. If the iron wire is now pulled through the drawplate, the spur on its further end will cut through each coil of the wire in succession. There are two precautionary measures which should be taken first, however. Slide a soda-water bottle over the coil of wire. The rings, when cut off, will fall into the bottle instead of flying all over the place. Put a brass washer on the wire before it goes through the drawplate. The washer will keep the spur from injuring itself against the drawplate when it has cut through the last coil. Rings other than circular should be cut through at some part of their circumference which will not show much in the completed work.

The extremities of rings cut from a spiral coil do not quite meet. Before using them in your work, they must be

straightened. Rings made from fine wire may be flattened by pressing them on a flat stake with the face of a hammer, but stouter rings should be gripped on either side of the joint by two pairs of snipe-nosed pliers. With a very little manipulation the ends may be brought opposite each other. If the ends do not quite meet, the ring should be gripped right across its diameter with the pliers, and a gentle pressure applied. This compression should be repeated in one or two directions across the ring to make it truly circular, care being taken not to press too hard, for the ring might then collapse entirely. The joints may now be soldered, though many workers prefer to leave the soldering until the work is being put together. A large thin ring is more difficult to solder than a small one. The ring may be bent until its ends spring past each other, and so are able to hold together when placed in contact; or the ring may be stood up on the charcoal against some support, its ends resting downwards in a scratch made on the surface of the charcoal to keep them from slipping; or it may be soldered after being pegged down on to the charcoal.

If you hold the end of a piece of fine wire near the tip of the bright blue blowpipe flame, it will melt and run up into a bead. This little mass at the end of the wire may be hammered out flat on the stake, and then filed into the form of a little leaf, the wire forming its stem. The end of the wire will melt easier if you dip it first into borax. To make a larger leaf, melt upon the charcoal a fragment of the metal you are using, and when it is quite liquid heat the end of a wire in the flame and thrust it into the mass. Directly they unite, stop blowing. The bead of metal will remain molten for some seconds, so you have time to press it flat on the charcoal with, say, the flat side of the tweezers. This will save trouble in beating out. A larger leaf still would be made from sheet metal with perhaps a wire soldered on for a stalk. Branches can be made by uniting a number of leaves made as above, or by beating them up from a sheet of metal by repoussé work. Fruit and flowers are made in

a similar manner. The old method by which seed pearls are used to represent grapes is also worthy of remembrance.

The making of various patterns of twisted wires is discussed in another chapter. It is not necessary here to emphasise the great decorative quality of this material, which is to be found on a large proportion of the objects made by jewellers and silversmiths. It is a pity, however, that of the many beautiful varieties of this work made by the old goldsmiths, so few, perhaps a dozen altogether, are used now. Wires used for filigree proper are generally flattened, not round, for wire which measures less in one direction across the section than in the other is easier to bend. It also keeps flatter on the background, if it has one. In filigree work a tracing of the design is fixed on to a flat stake with a few little pieces of wax. The wire to be used is bent to fit the curves with a pair of pointed pliers or tweezers. It is cut where required by resting it on a piece of brass, and then pressing the point of a very sharp chisel through it. The chisel cuts cleaner than a pair of shears or snips, however finely they may be set. Each piece of filigree wire after shaping may be stuck into its place on a thin piece of sheet iron with the gum solution. If, however, it is very important that it, or any other light piece of work, shall accurately retain the exact curves given it, it must be annealed before it is fastened into its place. This annealing is done either on or in a metal pattern made to the required shape.

It is not very easy to put twisted wires on to work neatly, for the solder has a great tendency to run to the wire and clog it. You must try to keep the flame from the wire until the remainder of the work is hot enough to melt the solder. You manage this as a rule by applying the heat to the underside of the work, or at any rate in such a manner as to keep the wire cooler than the part of the work to which it is to be soldered. If you allow the wire to get very hot it will stretch and refuse to go back to its correct dimensions again.

If a ring of wire is put round a setting it is well to join the ends first, for it is easier to keep in place so. If it goes on a plain tube you may file a tiny groove round the tube first just to make a home for it.

It is almost impossible to describe in general terms the manner in which the other motifs mentioned at the beginning of this chapter are carried out for jewellery. The various forms may be stamped, forged, swaged, pierced out, cast, electrotyped, raised, worked in repoussé or produced by a combination of several of these processes. Each fresh piece of work presents a new problem, and the experience of the worker must guide him in deciding which method he must adopt to solve it. To attempt here to grapple with all the problems which might arise would be futile. But in the various chapters in this book sufficient information may be found to enable the craftsman to do the work in a practical manner.

It will be well, therefore, to discuss next the manner in which the parts of a piece of jewellery may be brought together and soldered. Let us take first, as a simple example the soldering together of a group of two, three or four grains. Arrange them on the charcoal block. But, as they will probably roll about more than you wish, you may fix them in position by pressing them a little into the block with, say, the flat side of the tweezers. With the tip of the borax brush moisten each grain where it touches its neighbours. Then with the same tool pick up a tiny piece of solder and place it on the joint. See that the liquid borax quite covers it. Do this to each of the joints. Or, using a pair of finely pointed tweezers, dip the paillons of solder into the borax and then place them in position. The solder for such small work may be rolled down to size 1 on the metal gauge, and cut into paillons as small as you like, perhaps $\frac{1}{32}$ inch wide and long for a single joint between grains, but larger for a joint where three grains meet. You must be careful to avoid the use of too much solder on this light work. Sufficient must, of course, be used to make a sound joint. But any

surplus tends to make the work look heavy, and it is almost impossible to remove it afterwards by filing. Think first how much will be required to fill the joint and put on just that amount. It takes less time to cut a paillon of solder of the correct size than to try to remove any surplus afterwards.

To solder the work. Bring a very gentle flame near it, and apply the heat so that the borax boils up very quietly, without disturbing the grains or throwing the solder off. A sharp blast would almost certainly cause one or other of these troubles. When the borax has settled down increase the heat a little. But notice that the pieces of solder, being smaller than the grains, get red hot first. If you allowed them to melt they would run up into little beads themselves and perhaps stick on to one of the grains. But they would not be likely to make good joints between the grains. If, however, you are careful to heat up the grains first, and to let the heat reach the solder, sufficiently to melt it—only after the grains are red hot—then the solder may run between and solder them together. For solder will always flow to the part of the work which is hottest (if it is boraxed, of course). If the solder gets hot too soon, and it may, move the work away from the flame for a second or two to let it cool. Then bring the flame to bear on the work in such a manner as to get all the grains equally hot. The flame should come almost directly downwards on to the group. When the temperature of the work has risen sufficiently high, the lumps of solder will suddenly collapse and the molten metal run like water into the joint. Cease blowing instantly, and let the work cool down. It will be found that it is easier to unite two smaller groups to make a group of four or more grains than to solder them all at once.

The heat being applied to the upper surfaces of the various parts of the work, they naturally get a little hotter than the undersides, which are in contact with the charcoal. The solder, therefore, will have a tendency to spread over the upper surfaces. To overcome this diffi-

culty it is well, when possible, in soldering bosses or flat discs or other pieces which might be injured by the solder getting on them, to turn them face downwards and to do as much of the soldering as possible from the back. Of course, keep all borax away from a surface on which you do not want the solder to run.

It is usual to " boil out " the work in pickle after each soldering. This process dissolves all the fused borax on the work, and it makes the surface of the work clean again, ready for the next soldering. You will remember that gold and silver, as generally used by jewellers, contain some alloy, usually copper, and that some of this alloy gets burnt out from near the surface of the metal each time the work is made red hot. And that until the burnt matter (usually copper oxide), is removed from the surface, the work cannot be properly soldered again. The solder also generally contains some zinc,—a fusible metal, some of which is burnt out of the solder each time it is made red hot. It will be seen, therefore, that " boiling out," or scraping the surface must precede any subsequent solderings if they are to be successful.

In soldering a fresh joint near one previously made it is usual to paint the old joint with the borax solution; and the solder in the joint runs when the work is heated again. But should there be any danger of the work falling to pieces, and you decide that it would be better not to allow the solder in the earlier joint to melt again, you must cover it up with a thick layer of rouge, loam or whiting, mixed with water. This will protect the solder from the heat and prevent it from running. But you must be careful to keep every speck of these materials away from the joint, and from your borax-slate. For the solder will not run properly where they are. The pickles used to clean your work will not dissolve them either. It is necessary, therefore, to scrape or wash off this coating before " boiling the work out." You must also remove all the binding wire before the work is put into pickle. For if you are using a

copper pan to hold the acid solution a thin film of copper will be deposited on your silver, and this film is difficult to remove.

Instead of forcing the grains into the surface of the charcoal block for soldering they may be kept together in another manner. Make a solution of gum tragacanth and fasten the grains or other small pieces into their places with it. It will be found, however, that a small piece of thin sheet iron forms a more satisfactory surface on which to fasten them with gum than the charcoal block. The iron has this advantage also, that should you wish the work to be curved from side to side, or in any other direction, the thin iron plate on which the various parts are stuck can be made beforehand to take that form. When the grains or other pieces of the work are fastened in their places with gum, the work should be dried in a gentle flame before the joints are painted with borax or the solder applied. It is a good plan to keep a lump of gum tragacanth on the borax slate, and to give it a rub in the borax solution occasionally. It prevents the solder from moving about so much. When the work is meant to be kept flat, after it has been boiled out, it may be placed on a steel stake and carefully tapped level with a horn or boxwood mallet. Or a piece of work which is flat may be placed on a sandbag and bossed up by gentle blows from a convex-faced hammer or mallet.

The difficulty of applying borax and solder in the ordinary way to extremely minute work has led some goldsmiths to use them in another form. The difficulties are, of course, that the borax may displace some of the work when it boils up, and that it is almost impossible to cut the solder into small enough pieces for the purpose. The Etruscans in the fifth century B.C., formed patterns on their goldwork, Fig. 377, from grains measuring one hundredth of an inch in diameter, yet not a trace of superfluous solder can be found. Work as fine as this is seldom met with now. But very small work can be done in the following manner. Put some borax on a metal plate and heat it until every trace of

moisture has been driven off. The borax will, of course, boil up, subside, and finally melt. Grind the hard glassy material left on the plate, in a mortar, to a very fine powder. Take a piece of the solder you are to use and reduce that to a powder also—by filing it all away. All the parts of the work having been stuck into their places with gum tragacanth or rice-paste, sprinkle over them a sufficient quantity of the powdered borax and solder. This may be done with a spatula, or by means of the little vessel shown in Fig. 48. It is shaped like a garden watering can with a straight spout. The upper side of the spout-stay is roughened by making a number of little nicks across it with a file. Equal parts of the dried borax and solder are placed in the vessel. The little can is then taken in the hand and the nail of the forefinger repeatedly drawn over the roughened surface of the spout-stay. This sets up a slight vibration, which causes the contents of the can to be discharged in a thin stream. The heat should be applied very gently, and from below if possible. There will then be less danger of blowing any of the fine particles out of their places. To avoid this difficulty the late Signor A. Castellani, the Roman goldsmith, who first successfully copied the almost inimitable Etruscan gold grain work, was led almost to abandon the use of the gas jet and blowpipe.

The plan given above does very well with work which has to be soldered on to a background. But with open work much of the solder and borax would fall through and be wasted. A little vaseline or paraffin may, however, be mixed with the melted borax when it is being ground up. They may then be applied to the work in the form of a paste, by means of a spatula or brush. The solder may be mixed with it, or added afterwards. Melted borax prepared in the manner described first above, soon absorbs water again. And as the whole point of this method lies in the avoidance of moisture (which would cause the borax to boil up when heated), the borax should be used when freshly dried. But the best method for filigree work is that in which the

parts are stuck in their places with gum tragacanth and a little borax. The work is then annealed. Then a good coating of borax is put over all. The work is annealed again and the solder applied, in very small paillons, of about size 1 on the Birmingham Metal Gauge in thickness. The joints being well boraxed in this manner, the solder will keep in then and not wander over the background.

In repairing work keep a sharp look out for soft solder. Remember that you cannot use hard solder on any work on which there is any trace of soft. For the latter, when heated to a temperature sufficient to melt the hard solder would penetrate deeply into the work and "burn" bad holes in it, and it would form a hard, very porous alloy with the gold or silver. You must remove every trace of soft solder first, or give up any idea of using hard solder on the work at all. Soft solder may be removed from gold or silver articles without injuring them in any way. Scrape off all you can. Then take 8 ounces of hydrochloric acid, and one ounce of crocus powder. Mix them thoroughly in a bottle. Of this mixture take 1 ounce and add it to 4 ounces of hot water. Put the work in it, and keep hot until all the soft solder is dissolved. Another method is given on page 40. Remember also to leave a small hole in any hollow article for the escape of the air when you solder it. If you do not, it may explode.

CHAPTER VIII

THE SETTING OF STONES

Tools required and their uses.

STONES may be set in a number of different ways, though it has been found by experience that certain stones look better in one type of setting than in another. As a general rule, fine stones which are cut in facets, Fig. 49, gems, the beauty of which is largely dependent on the light which passes into and through them, look better in an open setting such as the claw or coronet. For in this setting, not only is the stone separated from its surroundings as a very precious thing, but light is able to pass between the claws to the underpart of the stone, and enter there, making the whole gem look more brilliant. On the other hand, stones which are flat, or which have the smooth rounded shape known as cabochon, Figs. 50 and 51, are generally put into one of the closer settings. But there is no invariable rule. The nature and shape of the stone, its position and importance in the work, should be considered in deciding whether it is to go into a coronet or cut down, gipsy or Roman, thread or rubbed over setting. For stones which are cut flat, or nearly flat, underneath, such as turquoises, half-pearls, opals or carbuncles, no opening is made through the back of the setting. But stones with a "culet" or point underneath generally go into a setting which has a hole cut right through the metal at the back; this opening being squared out wider underneath the shelf or bearer upon which the stone rests. The widest part of a stone—where its top and underside meet—is called the girdle, waist or shoulder. Part of a setting must support the stone below this point, or the stone would drop through the setting, and

part must come above, to hold the gem in. Stones which are not fairly level round the waist, or which are not well bevelled off above it, give rather more trouble in setting, so they should be avoided if possible.

The tools required for setting are—

1. One or two triblets. These tapering rods of steel are used for turning up and enlarging collets and rings. An old cotton spindle makes a very useful triblet. These spindles, which can be bought for a penny, measure about 15 inches long, and taper from ¼ inch to about $\frac{1}{16}$ inch in diameter. Other triblets, measuring up to about ¾ inch in diameter may be required.

2. A number of scorpers, Figs. 52 to 57. These are short cutting tools, fitting into small round handles. The handle being against the ball of the little finger, the blade of the tool is held between the thumb and index finger. Many workers prefer to have a handle for each scorper. But there is much to be said for the use of a single handle fitted with a screw chuck into which any blade will fit. In this case the scorpers are kept, points upwards, in a row of holes in a small block of wood. The tool required can be found and fitted into the handle in two seconds. Gravers and scorpers which can be bought ready made are generally far too thick at the back. To keep them in order a great deal of time has to be wasted in grinding away the superfluous metal,—a third to a quarter of the weight of the blade. The tools must, of course, have sufficient metal in them to be rigid, but any additional weight represents just so much labour to be thrown away. It is better to make one's own scorpers than to buy them. Use round tool-steel rods, Nos. 20 to 30, Stubs' Wire Gauge. Forge the tools to shape, harden and temper them, as described in Chapter XXX. They are known by various names: "flat" scorpers, Fig. 53; "round" scorpers, Fig. 54 (sometimes called "half-round"); "spitstickers," Fig. 55; "knife edge," Fig. 56; "bull-stickers," Fig. 57, and so on. They are sharpened to an acute angle on the oilstone. It is usual to try the point

on the thumb nail. If sharp, it will not slip at all, but will catch at once. If a bright cut is to be made by the scorper, the tool must first be rubbed quite bright on the blackstone. Should the bright cutting be required on a concave surface, the underside of the tool must be curved also, or the cut will not be clean.

3. Cement sticks, Figs. 60, 61. These are pieces of wood 4 inches long, ¼ to ⅜ inch diameter. At one end is a knob of cement, into which any small piece of work can be stuck. To make the cement, melt some resin and stir into it sufficient brickdust or plaster of Paris to make a thick paste. To fasten a piece of work on to the stick, warm the cement over a gas jet, and press the work into it. It will hold quite firmly when the cement is cold. If the underside of the work is very uneven, with recesses likely to become filled up with the cement, and thus give considerable trouble in cleaning out afterwards, it is well to cover the back of the work with gold beaters' skin before pressing it on to the cement. Cement sticks are sometimes made to taper like a meat skewer. They are smeared with cement and are useful for holding collets, settings and other small rings.

4. A wax stick. This is a conical piece of prepared wax attached to a small, round stick, 1 inch long. It is used for picking up stones to try them in their settings. It is composed of beeswax mixed with (1) Venice turpentine—a sticky material; (2) Venetian red—this colours and dries the mixture; and (3) Glycerine—very little of this is required. It prevents the mass from setting too hard.

5. Drillstock and drills. The former is the ordinary jeweller's tool, Fig. 62. Its use is almost universal, for, besides its simplicity of construction, it has the great advantage of requiring but one hand to hold and use it, leaving the other free to hold the work. The drillstock should be fitted with a screw chuck, for with this almost any drill may be used. Drills may be of any type. It will be remembered that the drill, when in use, rotates alternately from left to right and from right to left. So the cutting

edges of the drill may be sharpened so that in whichever direction the tool may be rotating it will cut (Fig. 58), or both edges of the drill may be sharpened to cut in one direction. For drilling partly through thin metal a flat-bottomed drill is used, Fig. 59. It has a small projecting point in the centre which keeps the drill from wandering. This drill is used to sink holes for half-pearls, turquoises or other stones which are flat underneath. A slight peck is made with a narrow, round scorper in the centre of the space to be drilled, for the point of the drill to go into. It is well then to drill a tiny hole for the centre point to get a start in. But do not drill this small hole very deeply.

6. Graining tools, Fig. 63. These tools are made from short straight rods of steel, one extremity of which fits into a small handle, like that of a scorper. The other ends in a cup-shaped but not very deep hollow; the tool is used to shape any small projecting point of metal into a neat boss or grain, by rounding over its top and edges. The tool is held between the thumb and second finger, the forefinger being on the top of the handle. The hollow point is then placed over the projecting piece of metal, and the tool gently rocked from side to side. It presses the metal into shape. These tools are made by driving a rounded punch into the end of a piece of steel rod which has been previously softened. The end of the rod is then filed so as to leave only a narrow rim, like a knife edge, round the hollow produced by the punch. The rim is smoothed up with fine emery and the tool hardened and tempered. The hollow end may be kept burnished by occasionally working it on a small steel boss or "fion," made in either of the two ways now described. Take a piece of tool steel, measuring, say, 1 inch by 1 inch by $\frac{1}{8}$ inch. Part of an old file will do. Make it quite soft by leaving it in a fire until the fire goes out. Bevel one edge of it to a wedge shape, see Fig. 67. With hacksaw or slotting file make a series of cuts $\frac{1}{16}$ inch deep across the tapered edge of the steel plate, leaving a little square piece of metal between each cut. These squares

will, of course, vary in size from nearly $\frac{1}{8}$ inch, down to a very small square peg of metal at the narrow end of the taper. Next round over each of these square pegs neatly with a file Make each one as smooth and round a boss as possible. Polish them with a buff and fine emery: afterwards with rouge. Then harden the plate, Fig. 68. It is not necessary to temper it. Set it in a small cake of lead so that it will always stand upright. Polish up the little bosses finally with Sheffield lime made into a paste with water. The use of this material enables the highest possible polish to be given to steel articles.

A simpler and quite as effective a way of making fions is the following. Take a piece of steel wire an inch long, file each end to a rounded point, the size that you wish the tool to be, for graining tools and the fions on which they are kept bright are made in various sizes. But half a dozen, running from $\frac{1}{16}$ inch downwards, are perhaps as many as you are likely to require. Make the points as true as you can. Then harden them, but do not temper. Put the tool in the drill-stock and rest the point on a fine emery buff. After a few turns of the drillstock the point of the tool will begin to penetrate the buff. Shift to another place. The fine emery will give an almost perfect polish to the point of the tool. You may also polish up the graining tool in the same manner. Another kind of graining tool, Fig. 64, has several, say five, little hollows in a row at its point.

7. Roulette, Fig. 66. This tool has a small wheel at its extremity with a row of shallow depressions round its circumference. These hollows produce a row of small bosses or grains upon any narrow edge of metal along which it is wheeled.

8. Push tool. A short brass tool set in a small handle like a scorper. It is made from a piece of $\frac{3}{16}$ inch brass wire. The point is slightly hollowed. The tool is used to press a stone firmly home into its setting.

9. The setting or pressing tool is a short square-ended tool of brass, set in a small handle like the last. It is used to

push the tops of the claws of a coronet setting over the edge of the stone. To avoid any danger of the tool slipping its point is roughened by beating it with a file.

10. One or two 6-inch lengths of $\frac{1}{8}$ or $\frac{3}{16}$ inch steel rod. The ends are filed to conical points varying in sharpness. A large cork pushed on to the middle of the mandrel serves as a handle. The use of these tools is described under "Thread" and "Roman" settings.

11. Clamp for drilling pearls or other rounded objects, Fig. 65. This is made from a strip of stout brass folded in half. A series of holes, varying in size, is drilled through the two halves. The inner edge of these holes is rounded off to give a safer grip on the object to be drilled, and to prevent any injury being done to it by the sharp edge of the hole. By moving up the sliding ring the pearl can be gripped quite firmly between the jaws.

12. Saw-frame and piercing-saws.

13. Several pairs of pliers, flat, snipe- and round-nosed.

14. Files of various shapes.

15. Shears

16. A pair of spring dividers.

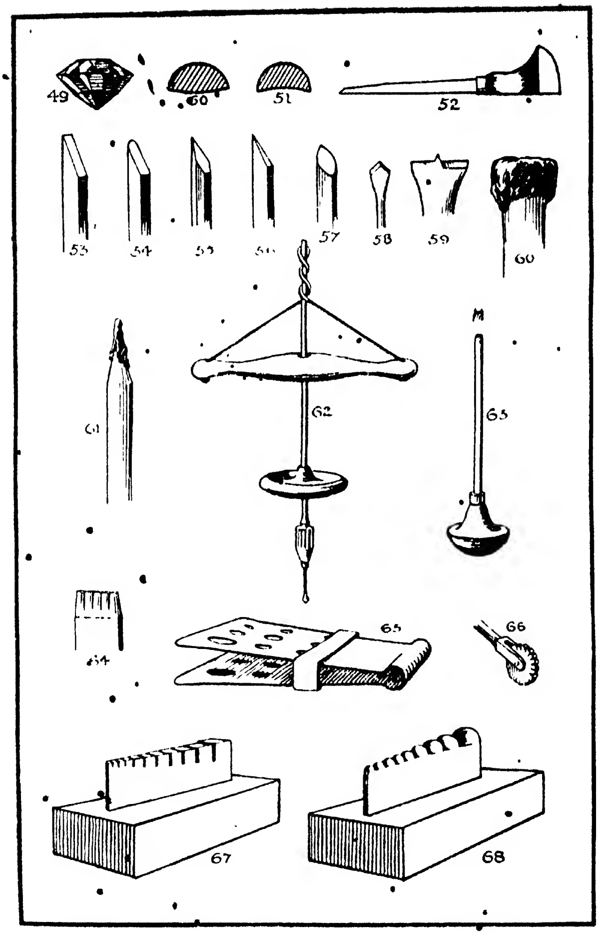
17. A punch with a matted surface.

18. An oilstone, a blackstone and a rubstone. The blackstone is used for producing a burnished surface on a scorper after it has been sharpened on the oilstone, when a bright or burnished cut is required. The rubstone is a flat-topped stone upon which work may be rubbed quite level. In fitting parts together it is a great convenience to be able to grind surfaces which are to come in contact quite flat and true.

19. Burnishers, Figs. 44 and 45.

20. Polishing materials.

21. Soldering materials.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CHAPTER IX

STONE SETTING (*continued*)

The coronet setting—The cut down—Millegriffe—Thread or thread and grain—Star, gothic or tulip—Pavé.

THE coronet or claw setting, Fig. 69. Take a piece of silver about size 14. Cut off a strip the height you wish the setting to be, and in length a little over three times the diameter of the stone. With a pair of round-nosed pliers bend the strip into a ring. It is difficult to bend the extreme ends of metal of this thickness, so with the piercing-saw cut the ring as marked, Fig. 70, to obtain a true circle. This is an easier way than that of hammering the ends of the strip into shape on a triblet, or in a swage or lead cake. The bending of the strip can, however, be done with a pair of pliers, one jaw of which is convex and the other concave. In goldwork the metal used would be thinner, say, size 10, and therefore easier to bend. Squeeze the ends of the strip together. They should fit exactly and form a ring, the outside of which is about equal in diameter to that of the stone. Tie the ring together with binding wire and solder the join. Slide the ring on to a triblet and give it a few taps with the hammer to make it quite circular. Pass a file across the top and bottom to true them. When a number of settings have to be made it is quicker to take a piece of chenier, *i.e.* tube, of the right size, and cut the rings, or collets as they are called, from it. Next fasten the collet on to the cement stick, right in the centre of the cement end. About half the collet to be left projecting from the cement. It is a good plan to use a pointed stick thinly coated with cement and to drive the end firmly into the setting, then to melt the cement. It will hold the collet firmly.

When the cement has set firmly, take a bullsticker, and with the outer, more curved part of its cutting edge level off the inner edge of the collet, Fig. 72, holding the stick against the bench pin and turning it to meet the tool. Turn the bullsticker in your hand and with the point cut a little shelf all round on the inside of the ring, rather more than $\frac{1}{16}$ inch below the top edge. On this ledge or bearer the stone will eventually rest, though the ring is, at present, too small to allow it to drop in. Be careful to leave sufficient metal in the rim to make the claws strong enough. Only a small ledge is necessary to support the stone, but it must be cut low enough in the collet to allow the rim to stand a bare $\frac{1}{16}$ inch above the edge of the stone when, later on, the stone is resting on the ledge. In Fig. 73 the stone is shown resting on its bearer, though there would not really be room for it until the claws were cut and bent out. The drawing, however, shows how the top of the bearer is to be sloped inwards to correspond with the pointed underside of the stone. Should the stone be pointed underneath, the edge of the bearer must be bevelled off to match. Stones vary in the thickness of their edge, or waist, and in the angle to which the culet, or pointed underside, is cut.

The next thing to do is to cut the claws. Their number will depend a good deal on the size of the setting. You may make them any shape you like. Carve them into leaves or waves if you will, using saw, drills, files and scorpers. But they must not be too wide and stiff to allow you to bend the tops of them over on to the stone when finished. Yet they must be strong enough to hold the stone and to stand any reasonable usage: $\frac{1}{16}$ inch or less is sufficient for their width.

To make a coronet with straight claws remove the collet from the cement stick. Take the piercing-saw, or a slotting or gapping file. This file is roughened only on the narrow edges, not on the sides, so it is useful for cutting narrow slots. With saw or file remove the metal from between the first two claws, commencing the cut just on the soldered

seam. Cut right through the metal to about half-way down the collet, and below that point slope the cut outwards down nearly to the bottom, Fig. 74. Consider how many claws there shall be. If an even number, cut next the opening which comes exactly opposite the one you commenced with. Afterwards the two at right angles to these, and so on for an eight-clawed setting. Be careful to make each claw exactly the same size. Then with a fishbelly needle-file narrow the claws towards the top, and with a round scorper (the underside of the point of which is slightly curved, and rubbed bright on the blackstone), true up the spaces between the claws. The lower part of the setting will now appear too heavy for the top, so make a series of cuts with a three-square, *i. e.* three-cornered, needle-file round the bottom also, one in a line with each claw. Take away sufficient metal to leave only a row of rounded points or teeth round the bottom of the collet. Finish these also smoothly with a fine file. See that the setting will stand up truly,—not leaning to one side. Next take a piece of silver, size 14, and cut from it a disc or "bezel," the size of the base of the collet. Take the collet and pass a fine file across all the points at once to make sure that they are of the same length. Tie the disc and collet together. Apply borax with a finely pointed brush, and with the same tool place a tiny paillon of solder by each point. After soldering, drill out the centre of the bezel, then take a three-square file and cut a groove all round its edge. This will make it look lighter. In Fig. 76 it is shown complete, although the groove round its edge is not made till after it has been soldered to the collet. Lastly, choose a round-ended repoussé tool which is a little larger in diameter than the top of the setting and press it gently straight down between the claws. It will force them all outwards and make them wide enough apart to receive the stone. The setting is now ready for polishing. Do this with threads and tripoli. It sometimes happens that several coronet settings have to be soldered together. To make sure that the tops of adjacent claws shall not be joined to-

gether in the process, it is well to bend them a little away from each other. They can be straightened up afterwards.

To set the stone; pick it up with the waxstick and try it in the setting. Bend the claws in or out as may be necessary. See that the stone goes fairly down on to the ledge provided for it. Hold it in place with the left thumb-nail, and push the tops of the claws over it with the square, roughened, brass setting tool. Claws on opposite sides of the stone should be attended to in succession. See that the stone is level in the setting. Press the claws well down, into close contact with the stone. Then with a sharp scorper cut the point of the claws into a V-shape, cutting each side and the top of the turned-down part of the claws. With the pointed end of a mandrel smooth the metal right down on to the stone that there shall be no possibility of anything catching in the claw.

Some jewellers, however, go about the work in a different manner. They make the setting to taper narrower underneath from the first. They make a rough sketch of the coronet, making it large enough at the top, in this case, for the stone to go in, and deep enough to cut the bezel from the same piece of metal. They produce the sides of the sketch downwards till they meet as shown in Fig. 77. Then with A as centre they make the two arcs B and C. They measure along B 3½ times the diameter of the top of the coronet D E. This measurement comes from D to F. Join F and A, cutting C in G. Then D F G H is the shape required. The jeweller cuts this out in the metal he is to use, bends it up for the coronet and solders it. It forms part of a cone, of the exact proportions of the coronet. But only if he is to finish and polish the work himself does he cut the bearer for the stone at this time, for some of the scraping and polishing which they receive might injure the claws if they were left thin at the top. So he leaves the bearer till the stone is ready for setting. With a file he levels the top of the collet, and then makes a mark with the dividers parallel to it, to mark the piece he is to cut off to form the bezel, Fig. 76. With a very fine saw, 0000, he cuts off the bezel

from the lower part of the coronet. He then cuts the points below the claws, K in Fig. 75, files these level and the top of the bezel true. He does this that the upper part of the coronet shall stand truly, without leaning. He then ties them together, solders them and puts the groove round the bezel as described above. He then cuts the claws themselves. After the polishing, the setter holds each claw in turn in a little nick filed in the side of the bench pin, and with a scorper cuts the bearer for the stone. Then with a pair of fine pliers he bends the top of each claw, above the stone, straight up, vertically. Some stones are so shaped underneath that it is not necessary to cut a bearer at all, their undersides being sufficiently supported on the tapering inner side of the claws. The setter now removes the stone and files the sides of the claws to a point. He then replaces the stone and with the pliers bends the top of the claws towards the stone, attending to two on opposite sides first, then to two at right angles to the first pair. He takes great care to keep the stone level on top. When the point of the claw is bent nearly into contact with the stone he files the end to a nice shape. Then with the setting tool he presses it right home.

Setters do not, however, all go about the work in the same manner. Another way of closing down a coronet setting is that of using a closing tool. It is used for rather thin coronets—those made from gallery, for example. The tool is shaped almost like a graining tool. It has a deep conical hole at the end, and is large enough to fit over all the claws at once. The tool is pressed firmly down on to the setting and rocked from side to side. It forces the top of all the claws inwards at once. It can only be used when the claws are of fairly thin metal. Coronet settings can be bought ready-made, as also can gallery—the material from which such settings are made. It is in the form of long strips, variously ornamented, with claws along one edge. A sufficient length is cut from the strip to fit round the stone and, when soldered, the coronet is complete.

The cut down setting, Fig. 78. This setting is often used for a fine stone, in a tie pin, for example. Cut a strip of silver, size 14, the height you wish the setting to be, and long enough to form a ring a little larger in diameter outside than the stone. Join it up and cut the shelf or bearer for the stone as described above. In this case, however, the setting must be large enough for the stone to fit right down on to its bearer as in Fig. 73. Test the fit of the stone from time to time while cutting. It should fit very accurately. With a pair of dividers make a light scratch round the setting at M, and below this scratch bevel off the lower outside corner of the setting, as marked in drawing Fig. 79. Fix the pin socket or ring, if one is required. All the soldering must be completed now, before the stone is set. If the setting is an open one, polish the inside of it. Put the stone in the setting, and press the edge over with the rough-ended brass setting tool, then rub the rim of the setting down as closely as possible to the stone, using a rough pointed mandrel for the purpose, Fig. 80. Next take a flat scorper and cut away sections of the rim, leaving narrow ridges standing out at intervals round the setting. The cuts to commence near the stone at the top, and to slope outwards to the lower angle of the collet, Fig. 81, M in the section, where the cut ends and no metal is removed. The ridges or "points" thus die away to nothing at M, but are the original thickness of the rim at the top; and they are separated from each other by a plain surface which slopes outward from the edge of the stone to the corner M. At first leave the ridges the same width all the way down. It is easier to get them equal and straight thus. But when they are all spaced out equally, taper each one so that it is quite narrow at the bottom. Round off the outer surface also. Then with a pointed mandrel and with a grain tool work round the upper part of the points, where they overhang the stone, rubbing the metal right down on to it. The setting may now be stoned, polished with threads and crocus, and finished with

A variation from the cut down setting is known as "mille-griffe," Fig. 82. In this setting proceed as described for the cut down setting to the point when the edge of the setting is to be rubbed down on to the stone. A row of little grains separated by minute cuts has now to be formed close round the edge of the gem. Remove the stone and bevel off the top inner corner of the setting with a bright scorper. The cut must not extend far downwards towards the stone. Indeed, it must only just bevel off the inner edge of the rim B, Fig. 83. With the dividers scratch a line parallel to the top edge of the setting to mark the lower limit of the graver cuts, unless you like to take them down to the corner which corresponds with M, Fig. 79. With the setting tool press the rim in over the stone so that the angle below the bright cut surface, B, keeps the stone in place, Fig. 84. Then take the graining tool, Fig. 64, which has the row of hollows in its point and press it on the top edge of the setting with a slight rocking motion. It will mark out and partly form several of the grains. Shift it along and mark some more. Go right round the rim with it. Then with the spitsticker make the cut between each grain, down to the scratched line. True up the tops of all the grains with the graining tool. They should be small and very even, for the slightest irregularity shows. To smooth up the outer sides of the grains take a brightly polished spitsticker and drag it sideways across the ridges. It will bump down into the hollows between them and scrape off any irregularities, leaving both ridges and hollows with a burnished surface. The effect of this setting is very light and dainty.

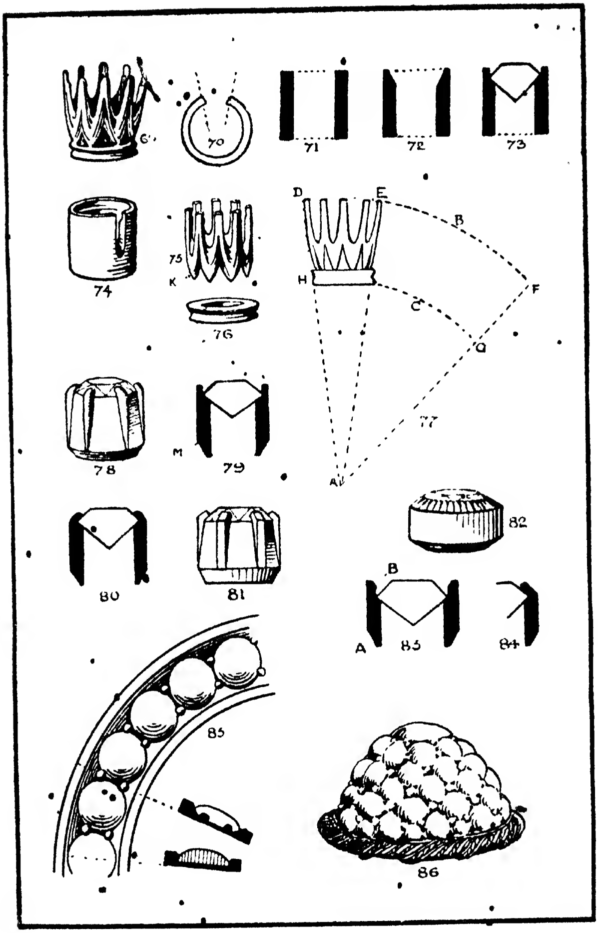
The "Thread" or thread and grain setting, Fig. 85. This type of setting is frequently used when a number of stones are to come close together. Put the work on a cement stick, wet the stones on the tongue and arrange them in their places. The stones must be placed as closely together as you can put them. They should just touch. When all are in order make a mark with a spitsticker between each stone. A hole must now be drilled for each. Make a slight

peck in the centre with a narrow, round scorper to make a start for the drill. It is safer to use a drill rather smaller in diameter than the stone, though quicker to use one the exact size, if you are quite sure of it. But it must on no account be too large. For pearls, turquoises and other stones which are flat underneath it is not necessary to drill right through the metal. The rule being that for collet stones, *i.e.* stones which are cut to a point underneath, the settings are always drilled right through. The recess for the stone should be made just a little deeper than the shoulder or "girdle" of the stone. If, however, a pearl or a turquoise is so thick at the edge that it would require a hole deeper than the metal would allow, file the back of the stone. To do this make a small dent or hole in the board pin and turn the stone face downwards into it. Use a fine file and wet it slightly before you begin. If the metal for the setting is thin it is well to use a drill which is nearly flat across at the bottom, with a point in the centre to keep it true, Fig. 59, You can drill with this until the centre point begins to push out the underside of the metal, if necessary. It is well to clear the way for this centre point by first drilling a fine hole for it a little way into the metal. While drilling turn the work to see that you keep the same depth all round. When you have gone deep enough, open out the hole with the bullsticker, turning the work round and round as you proceed. With the waxstick pick up the stone from time to time and try it in the hole, pressing it in with the thumbnail or against the pin. When the stone fits exactly go on to the next, and so on until all the holes have been opened out. Then if the holes are pierced right through the metal, open out each one underneath to a square shape, using piercing-saw and three-square files. When the work is backed, that is to say, made of two plates of metal of different qualities, one soldered behind the other, you may drill the holes right through the front plate before the back plate is soldered to it. This method saves time.

To set the stones. With the waxstick put the first in its

hole, press it well home either against the pin, or with a brass hollow-ended pushing tool. With a pointed mandrel or the tang of a file, pointed but not very sharp at the end, make a few snicks at intervals round the stone. Each snick on the metal to be made directly towards the edge of the stone. The effect of these snicks will be that a tiny scraping of metal is driven up against the stone, holding it in its setting. Go on till you can no longer lift the stone out with the waxstick. Then run the tool once or twice right round the stone, the side of the tool rubbing against it. This will drive up a line of metal all round the stone which will grip it firmly.

The grains are to be put in the corners wherever two or more stones meet. A series of grains, varying in size can also be put to fill up any tapering spaces where there is not enough room for additional stones. To make the grains. Take a spitsticker, and make a deepish cut, about $\frac{1}{16}$ inch long, towards the spot on which you wish to form the grain. At the end of the cut, when the tool has nearly reached the corner, and while its point is still deeply embedded in the metal, lift the handle of the scorper until the tool stands nearly at right angles to the metal. It is necessary to hold the point of the tool firmly into the cut during this movement. The little curl of metal thrown up by the tool just beyond the end of the cut will be forced against the stones. This is the material from which the grain is formed. Now take a grain tool of suitable size. Hold it between the thumb and second finger, with forefinger on the top of the handle. Put the hollow point on the curl of metal and gently rock the tool from side to side. The cup-shaped hollow in the tool will form a round-topped grain, which should slightly overlap the adjacent stones. Do not press the grain down very flat. Keep it high, and smooth, and bright. When all the grains have been finished, true up all the metal near by, cutting downwards to the edge of the stones with a spitsticker. The grains will hold the stones firmly. Finish with a spitsticker which has been rubbed bright on the blackstone. The thread of metal which gives its name to this



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setting is left as a sort of outline to the group of stones and grains, preserving the shape of the leaf or scroll, as the case may be. It is just a narrow edge of metal, cut smooth on top with a flat scorper. Keep it as close to the stones as possible. Make the scorper bright underneath before cutting. Settings are cut brightly in this way for pearls or soft stones, so it is not necessary to polish them. There would be some danger of ruining the pearls if that were done. A little dry plaster of Paris is generally put into the bottom of the setting for a pearl. It makes the white backing which a pearl requires. A small piece of suitably coloured foil may be put at the bottom of the setting to brighten up, or tint a stone.

"Star" setting is a variation from the thread and grain setting. It is used for single stones set in plain surfaces. The grains hold the stone in securely, and the rays of the star radiating from it enhance its importance. In the case of a pearl or other soft stone the rays would be bright cut, but for diamond, or other work which will be polished afterwards, bright cutting is not necessary.

Yet another variety is the "Gothic" or "Tulip" setting. Instead of the straight rays of the star a series of scallops is cut round the stone with a round, bright scorper. The stone is kept in place by grains, like the last. In "Pavé" setting, Fig. 86, the stones are arranged as closely together as possible, the grains which keep the stones in place being the only metal left in sight. The work is done in the way described above for thread and grain work.

CHAPTER X

STONE SETTING (*continued*)

Gipsy or flush—Roman—Rubbed over or band setting—Cramp setting—Pin setting for pearl—Drop stones, etc.

The Gipsy or Flush setting, Fig. 87. In this setting the metal comes smoothly right up to the stone, without any claws or grains, the stone looking as though it had grown in the metal.

Drill and open out this setting as described above for the thread setting. Make sure that the stone fits very accurately. But it must not be sunk too deeply. Take a half-round file, and to the depth of about $\frac{1}{32}$ inch, file down the surface of your work, leaving untouched, however, a little ring of the metal just round the hole you have been at work upon. The inner edge of this little circular bank of metal, which forms the side of the hole, is, of course, vertical. The outer edge slopes away, and the bank may be $\frac{1}{16}$ inch wide at the bottom, Fig. 88. To set the stone, press it well home against the board pin, or with the pushing tool. Then with hammer and a matt-ended punch drive the metal in the circular bank gradually towards and on to the stone. In the case of pearls and the softer stones considerable care must be taken not to chip them. The punch used has a rough surface, as it is less likely to slip than a smooth ended tool. Now burnish the metal right up to the stone. By the time that the metal has closed down on its edge, the little circular ridge of metal left round the stone by your filing will have disappeared, and the surface of your work is fairly level. It should now be filed true and quite level right up to the stone, leaving no visible evidence of the manner in which the gem has been fastened in. If you care

to do so, you may with the punch drive the metal down on to the edge of the stone immediately the hole has been opened out, leaving the filing until afterwards. In this case the metal round the edge of the stone will be sunk by the punching to a lower level than that further away, see Fig. 90. This is put right when you file all the surface level.

A seal stone is set in much the same way. When the stone comes from the lapidary its corner B, Fig. 91, is generally quite sharp. With a corundum file grind off the extreme corner so as to form a new edge, less than $\frac{1}{32}$ inch wide, Fig. 92. Pierce out with the saw the hole in the ring, if it is for a ring. Then with the outer side of the bullsticker bevel off the edge of the hole to the outline of the stone, and cut the bearer. When the stone begins to go into the recess you are cutting, it will either jam or rock on some projecting part. If it gets firmly jammed in, push the wax stick firmly on to the stone, then give the stick a sharp blow with the handle of a file. This will generally bring the stone out. To find out how it rests, mix a little crocus and oil, and put a very thin film of it on the underside of the stone. Then press the stone into the setting. The crocus will show exactly where it touches. Go on cutting until the stone fits firmly on to its bearer. Then with a round scorper cut a channel or gutter C, Fig. 93, on the surface of the metal, all round the hole and quite close up to it. To set the stone, take a mandrel with a blunt point and rub hard with this tool in the gutter C, until the ridge of metal between the gutter and the hole for the stone is driven over the edge of the stone, or drive the intervening ridge down with the matted punch. Work with the mandrel until the side of the tool is rubbing against the stone itself. The metal will by this time have completely closed over the little edge made by the corundum stick, and will hold the stone firmly. Rub the metal carefully down just against the stone. With a round scorper true up any inequalities. Polish with slate stone, with crocus, and finally with a dogwood stick and rouge. This setting is known by the name of "Roman."

The "rubbed over" or "band" setting. This can be used for stones of almost any shape, but is more suitable for cabochon cut than faceted stones, for the unevenness of the latter makes the edge of the setting irregular. It is one of the simplest settings to make. Take a piece of sheet silver, size 4 or 5, and cut off a strip a little wider than the height you wish the setting to be. Bend it round, Fig. 96, and cut off sufficient to barely reach round the stone. The ring or "bezel" made from the strip can always be stretched a little by sliding it on a triblet and giving it a few taps with the hammer, but only by cutting a piece out can it conveniently be made smaller. It is therefore better to cut the band too short than too long. Tie the ring together with fine binding wire. Solder and file up the join. Make the ring true on the triblet and see that the stone will slip into it. Level the top and bottom with a few strokes on the rubstone. Then, if the setting has not to be fastened on to a larger piece of work, back it with a thin piece of whatever metal you are to use for the back of the setting. Cut a piece rather larger than the ring, and tie the two together with wire. But if the ring shows any inclination to get out of shape, or if it is for an irregularly shaped stone it is better to proceed in the following manner. Put the stone in the ring and place both on the backing. Then with a graver drive up a number of tiny curls of metal against the ring. The graver cuts need not be more than $\frac{1}{32}$ inch long, but the little curls of metal driven up by them will effectually prevent the ring from twisting out of shape during the soldering. Remove the stone, and tie the ring and backing together. Borax the joint and put paillons of solder on the backplate where it projects beyond the ring. Then solder. If you are to decorate the setting by a ring of twisted or other wire, do it now. Next boil out in pickle. Afterwards cut off all superfluous metal, using the shears right up against the ring, or the wires if there are any; and file up tidily. If, however, the setting is to be open at the back, either solder in a bearer for the stone to rest on, or

back it as already described and cut out with the piercing-saw as much of the back plate as possible, leaving only a very narrow edge for the stone to rest upon. File up the opening neatly.

When a number of settings of about the same size have to be made it is easier to take a piece of tube of the correct diameter, and cut it into suitable lengths, instead of turning up each band separately. In setting stones or other objects which may be irregular in shape at the back, it is sometimes convenient to make the bearer from a ring of wire or a short piece of tubing made to fit the back of the jewel.

To set the stone. If it requires any foil or backing first put this in the setting, then press the stone well home. See that the top edge of the setting projects $\frac{1}{32}$ inch, or less, above the shoulder of the stone all round, Fig. 94. The top of the rim is now to be pressed over the edge of the stone. This can be commenced with the brass pushing tool and completed with the pointed mandrel. Take care to rub over an equal amount all round, so as to form a little flat edge close round the stone. Then with a small warding pillar file, with its smooth edge towards the stone, file round the setting to make the little edge quite true, Fig. 95. The work is now ready for polishing. Another way of closing the band setting is that of running a roulette round the rim. This crushes down the edge sufficiently to hold the stone in. Yet another way is that in which a pushing tool, the point of which is rounded from side to side, is used to press portions only of the rim of the setting against the stone, see Fig. 97. In setting a stone thus, it is well to press in a portion of the rim, say, at the two sides of the stone in immediate succession, then at the two ends in succession, and afterwards at the intermediate positions. A flat scorper is then used to true up the wavy top of the rim.

In old work band settings were often made quite tall and conical, a ring of wire soldered inside near the top acted as bearer for the stone.

"Cramp" setting. This is a variation on the rubbed over setting, and is much used for fragile objects. Turn up a thin band to fit round the stone and join it. Fit a bearer within upon which the stone can rest. The band must be wide enough to project about $\frac{1}{16}$ inch above the girdle of the stone. Parts of the border are now filed away, leaving claws or "cramps" standing up at intervals round the setting. First with the dividers scratch a line parallel to the top of the setting to mark the lower limit of the claws. Then file away sections of the rim above the scratched line, taking care to leave the cramps strong enough. The spaces between the claws may be filed to a knife-edge on top, Fig. 98, or they may be serrated. In another form of cramp setting the top edge is nicked at intervals with a three-square file, leaving projecting teeth like those on a saw, Fig. 99. To set the stone it is only necessary to press over each cramp or tooth with the setting tool.

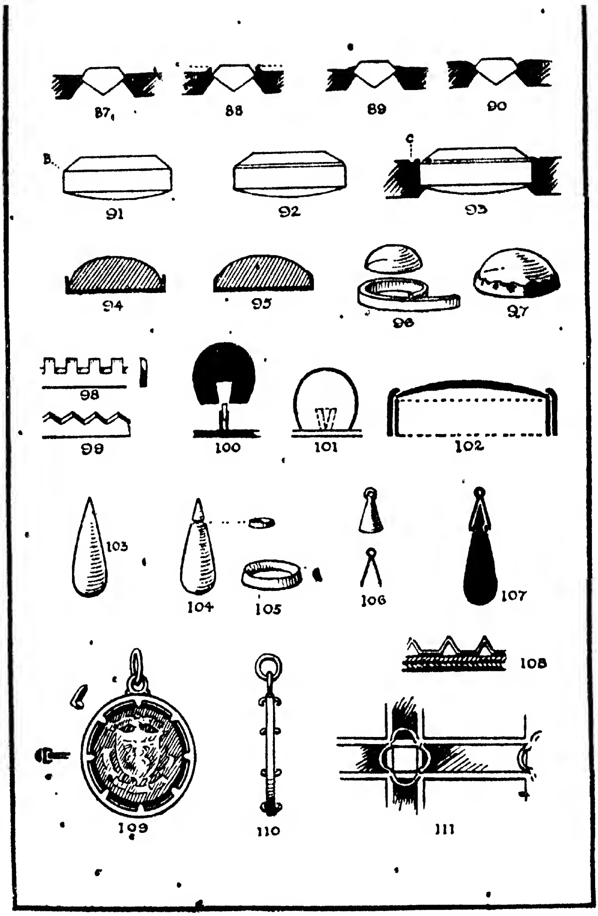
An enamel, a cameo or other object upon which you may prefer not to risk the effect of any pressure, can sometimes be set from the back of the work thus, Fig. 102: Take a strip of metal long enough to go round the edge of the enamel, and considerably deeper than its thickness. Make from it a ring or collet into which the enamel will fit, and curl its top edge inwards, above the enamel. Make a second ring which will fit tightly into the first. This second ring is to keep the enamel in its place below, for it will act as a bearer. It may be fastened firmly by short pins passing through both rings, or by means of soft solder. The back of the enamel may be covered with a piece of thin sheet metal; or used as a frame for a glass, as in a locket.

A pearl (not a half-pearl) is usually drilled half-way through from the back. A pin, notched and roughened, is soldered on to the setting to correspond with the hole in the pearl. The latter is then cemented on to the pin with shellac, mastic, diamond cement or some other adhesive. A screwed pin fitting into a tapped hole in the pearl makes

a better job, but great care must be taken not to split the pearl. One side of the screw should be filed flat, for it gives a little clearance in cutting. A split pin is sometimes used instead, Fig. 100. The hole in the pearl is drilled as before and then widened out inside. The pin is made from two pieces of half-round wire, or a round pin is split lengthways with the saw. A small wedge is next made to fit between the two halves or the pin. The wedge must be shorter than the split in the pin, and it must not be so thick at its wider end as to force the two halves of the pin further apart than the widened-out hole in the pearl will permit. To set the pearl it is only necessary to place the point of the wedge between the two halves of the pin, apply the cement, and finally to press the pearl home. The wedge will force the two halves of the pin apart inside the pearl, making it impossible for the latter to be afterwards withdrawn, Fig. 101.

To set a drop stone, Fig. 103. A groove is cut by the lapidary round the upper end of the stone Into this groove a small ring is fitted, projecting very little above the surface of the stone, Figs. 104 and 105. A mount or cap is now made to fit over the ring and upper part of the stone, Fig. 106. The inner surface of this cap is coated with soft solder—"pewtered." When the cap is placed in position very little heat applied to it is sufficient to firmly unite cap and ring, Fig. 107. A bead or ball pendant is generally drilled half-way through from the top. A roughened wire projects from the cap and is fastened into the hole in the stone with cement.

To set a coin as a pendant, Fig. 109. Make a ring of wire rather larger in diameter than the coin. At intervals round its circumference solder on small clips, projecting each side of the ring. When the coin is put into the ring the clips can be pressed against it on either side. Another way is to solder short lengths of wire across the ring above mentioned. Each end of these short pieces is afterwards curved back with the pliers to rest against the coin and keep it in place, Fig. 110. Do not forget the loop for suspension.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In old work pearls were very often drilled right through and fastened by a fine wire which ended in a tiny coil or bead against the stone.

In the Treasury of St. Mark's at Venice is a Byzantine book-cover decorated with gold filigree, jewels and enamels. It has many oblong stones set in cells of beaded wire with a half-ring of plain wire soldered at each end of the cell. These half-rings are bent sideways over the ends of the stones, and hold them firmly in place. Whenever four stones meet, as in Fig. 111, the four bent half-rings give the effect of a rosette. On the Cross of Cong, in the National Museum, Dublin, are some settings made from two rows of twisted wire surmounted by a single zigzag wire, as shown in Fig. 108. The projecting parts of the top wire are bent over the jewel.

Diamonds are set in silver or platinum, for these metals do not interfere with the colour of the stones as gold would. Silver mounts are, however, backed with gold—a stronger metal. The openings through the settings under the stones are squared out behind with the piercing-saw; the dividing lines between adjacent stones being filed away underneath with a smooth three-square file. The filing is continued until there is only a fine edge of the mount or setting left. But of course due regard must be paid to strength. So, in a cluster, alternate holes would be left perhaps with a circular opening underneath. With large pieces of work the craftsman would leave thicker bars here and there, arranging them so as to form a pattern.

CHAPTER XI

RAISING

Stakes—The raising hammer—Planishing and collet hammers—Sinking—Raising—Annealing—Shaping—Planishing—Various hints.

HOLLOW vessels of almost any shape may be hammered from one piece of sheet metal without a join. This process is known as raising. In modern workshops it has been largely abandoned in favour of spinning—a method by which the sheet of metal is burnished into shape on a lathe. Spinning is very generally used where many copies of the same article are required. But for its freedom from limitations and its personal qualities raising always holds its own for artistic work.

The tools required for raising are—

A number of stakes. The T-stake, Fig. 112, is an extremely useful one. The raising of work of almost every shape is commenced on this tool, though it may be completed on another. The stake is made of iron, steel-faced. The arms are each about 12 inches long, elliptical in section, one measuring about 2½ inches wide by 1 inch deep at the end, the other about 1½ inches by 1 inch. This tool either stands permanently in a large block of wood, or it can be held in a vice. As a substitute for this stake a rod of steel or brass, 12 to 18 inches long and 1½ or 2 inches in diameter, may be used. Its efficiency is increased if one end is slightly flattened on top and the extremity undercut to make an angle of about 70° with the upper surface, as shown on the drawing of the T-stake. Large bowls may be raised even on wood. The bickiron also, Fig. 113, is T-shaped. In this tool one arm is flat on top, and the other circular in section, tapering from about 1½ inch diameter at the shoulder to

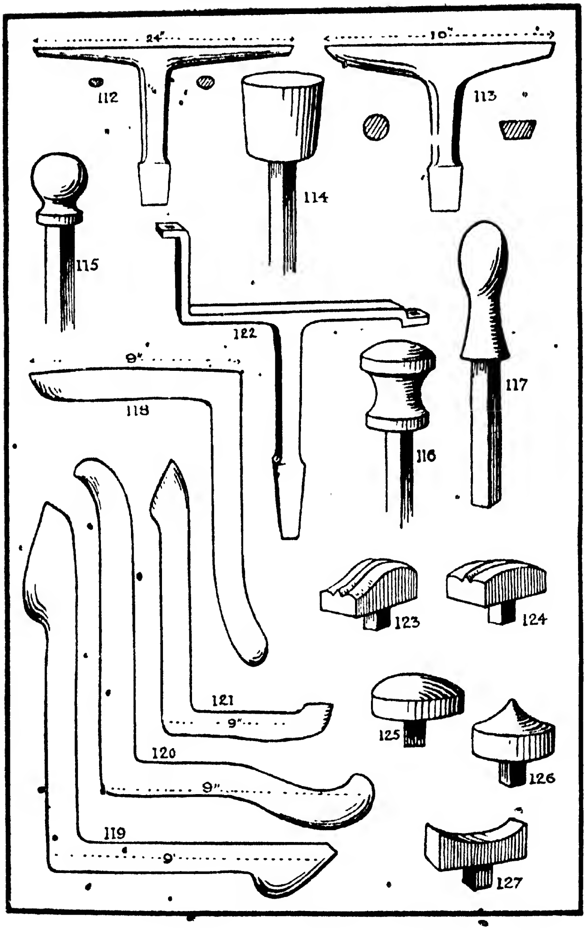
½ inch at the end. Bottom stakes, Fig. 114, are flat on top and circular in plan. Three inches and 1½ inch in diameter are good sizes; the shank should be 9 inches long and not less than 1 inch square. These tools are used for levelling the flat bottom of bowls and for other work. Round-headed stakes, Figs. 115 to 117, have many uses. Some of the most valuable stakes are those shown in Figs. 118 to 121. Upon them work of almost any form may be shaped and planished. These tools can be made by a blacksmith in mild steel, or in iron, from bars which must not be less than 1 inch square. If made from material ¾ inch square they are not rigid enough. Another tool is called a horse, Fig. 122; at the end of each arm is a small square hole into which goes the shank of a small stake. The long arms enable the small stakes to be applied to almost any part of the work. A number of small stakes fit on to this horse. They are made in many shapes, fluted or smooth, Figs. 123 to 127.

A sinking block. This is a piece of wood with several shallow circular depressions cut in it. These hollows may range from about 8 inches in diameter and 1½ inch deep, to 2 inches by ½ inch. Pieces of metal can be sunk to a rough saucer shape in these hollows by means of a round-faced mallet or hammer. The sinking block is often made from a piece of tree trunk 2 feet high, with the depression cut in the top.

A vice. This should not weigh less than 65 lb. It should have jaws at least 5 inches wide. Vices of 50 lb weight or less are not rigid enough to prevent vibration. The vice should be firmly bolted to the bench, and that to the wall or floor, for it must be quite firm.

Several hammers. It is most important that these should be of the proper shape, as their efficiency is thereby vastly increased.

The raising hammer is shown in Figs. 128, 129. It has two faces, each measuring 1¼ by ⅜ inch. They have all the edges and corners well rounded off. This is especially necessary in the case of the front corners, *i. e.* those furthest from the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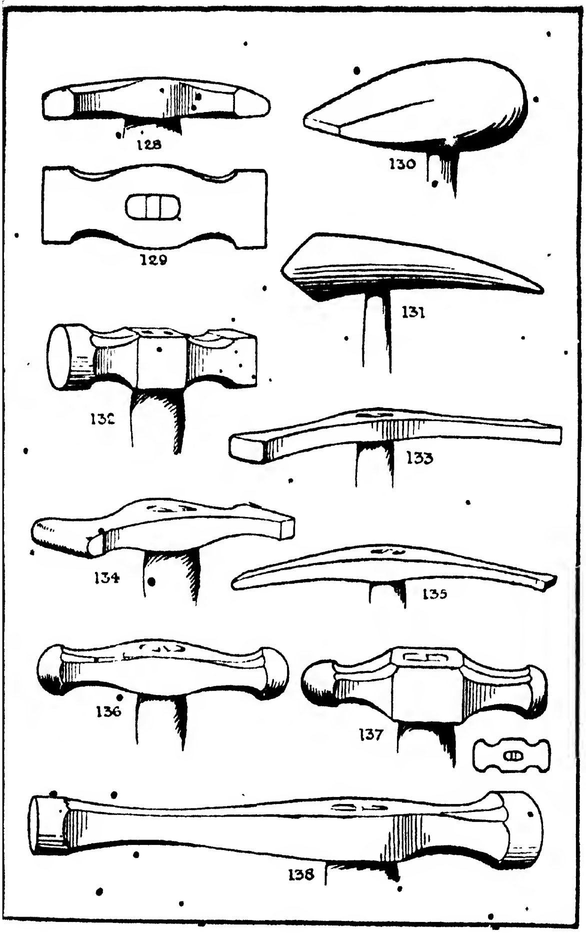
handle, for if they are not sufficiently rounded they are likely to cut into the work, and thus give more trouble in planishing. For the same reason the face of the hammer is made as wide as 1¼ inch, for it has been found by experience that a wide-faced raising hammer cuts the work about less than a narrow one. The face of the hammer in most general use is flat in section. The other face is rounded, as shown in the drawing. The weight of the head is about 8 oz.; and the hammer has a handle over a foot long, indeed, 16 inches is not too great a length. Some craftsmen use a hammer with a circular face, like the left side of that shown in Fig. 132. If, however, they were to give the hammer shown in Fig. 128 a fair trial, they would hardly be likely to go back to the other. The straight-faced hammer is certainly the more efficient tool.

The second raising hammer is like the other in all respects except that the thickness of the face is ⅛ inch instead of ⅜ inch. The handle may be rather shorter.

The raising mallet, Fig. 130, or a horn tip, Fig. 131, may often be used instead of the raising hammer. The horn tip is the end of a bullock's horn. It is sometimes weighted with lead. The face of each of these tools is cut to a wedge-shape. The thickness of the wedge at the point is about ¼ inch. These tools do not bruise the metal so much as a steel hammer does, so there are fewer marks to remove in the final planishing. Italian coppersmiths seem always to use the mallet in preference to the raising hammer. It may be well to note in this connection that there is one very definite difference between the silversmith and the coppersmith in his manner of holding a bowl-shaped vessel while raising it to shape. The silversmith holds the bowl with its opening turned away from him, as shown in Figs. 139 to 142, while the coppersmith puts his bowl on the far end of the stake with its opening towards him. And each craftsman is certain that his own is the correct way.

The planishing hammer, Fig. 132, has two flat faces. One may be circular, the other square. Beginners may find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considerable difficulty in managing this tool properly, for, in unskilful hands, its sharp corners leave marks at almost every blow. The secret of its successful use lies in a certain stiffening of the wrist. Try to bring the hammer down "dead true" each time, and the wildness of aim which is responsible for the trouble will disappear. But, to begin with, a planishing hammer whose sharp corners have been rounded off should be used.

Collet hammers. These are shown in the illustration, Figs. 133 to 135. They are made in a variety of sizes to suit the very varied uses to which they may be put.

The ball-faced hammer, Fig. 136, is used for bossing work up from the back and for a number of other purposes. So also is the sinking hammer, Fig. 137, whose principal work, however, is that of sinking the central, depressed portions of round trays and other objects. The hammer shown in Fig. 138 is for work inside bowls—levelling the bottom, for example.

A pair of compasses with quadrant, if possible, and a pair of callipers.

Snarling irons.

Blowpipe, bellows and a hearth upon which annealing and soldering can be done.

The great majority of shapes to be raised—bowls, cups, vases, etc., though differing widely in profile, are all more or less circular in plan. They are, therefore, all raised from circular pieces of sheet metal. It is usual to take a disc of metal rather less in diameter than the combined height and width of the bowl you wish to make, if the metal is of a fair thickness, say size 12 on the metal gauge, or thicker. A tall, narrow shape requires less metal than a shallow one of the same combined measurements. A hemispherical bowl 6 inches in diameter can be made from a disc 8 inches in diameter, size 12. If the metal is thicker than this and you care to thin it in hammering, of course a smaller piece will do. A bowl can be made either from a small piece of very thick metal or from a larger, thinner piece of the same

weight, the latter taking less time. But metal thinner than about size 8 on the metal gauge is very difficult to raise. The sizes between 10 and 16 are the best to use. A little bowl may be sunk out of a five-shilling piece, the inscription on the edge being left intact. To do this take a round-faced hammer and strike repeated blows in the centre of the coin, on a flat stake. The metal will go hollow on top, and the hollow can be made deeper and deeper by continued hammering. The work can, after a time, be turned over on the rounded stake and shaped and planished smooth. Do not omit to anneal pretty frequently.

The fruit stand shown in Fig. 165 measures nearly 6 inches high, 7¼ inches across the bowl, 5 inches across the foot. Depth of bowl, 2½ inches. Narrowest part of stem, ⅞ inch. The bowl, being very shallow, will require a disc 9½ inches in diameter. The foot, which is a shape which will take a good deal of hammering, will come out of a disc 6½ inches in diameter. Both discs are of silver, size 14 on the metal gauge. File off the rough edges of the discs, so that they may be comfortable to handle. With the round-faced mallet or hammer sink the discs to a rough saucer shape in one of the hollows of the sinking block. If the metal now feels hard and springy, anneal it. To anneal is to soften the metal by making it red hot. Remember that copper may be quenched while red hot, but for brass or silver it is safer to let the metal cool a little before putting it into the water or pickle. Take the compasses and round the centre of the convex side of the metal, lightly scratch a circle 5½ inches in diameter on the larger disc and one 1½ inch in diameter on the smaller. From these circles the raising will commence. Place the T-stake in the vice or in its block.

Hold the larger disc of silver with its concave side against the end of the larger arm, with part of the scratched circle opposite the upper corner of the tool. The upper edge of the disc of silver should be held by the left forefinger about ¾ inch above the top of the stake, the forefinger resting against the top or side of the tool. Now, with the flatter

side of the raising hammer, strike a sharp blow a quarter of an inch above the scratched line, Fig. 139. The force of the blow must be sufficient to carry that part of the metal touched by the hammer downwards against the top of the stake, Fig. 140. It is essential that the metal be driven right against the stake, so a second blow must be given in the same place if the first has not been completely successful. A sharp click or ring from the stake will announce that the blow has got right home. Turn the metal a little, still keeping the scratched circle opposite the upper corner of the stake, and strike another blow beside the first. Continue this process right round the circle, taking care that at each blow the hammer gets home. The front edge of the hammer face should produce a very definite groove, or rather angle, between that part of the metal with which it has been in contact and that further from the centre of the disc. To ensure this it is well to hold the elbow rather high and to notice from time to time that the front edge of the hammer face is doing its work properly. Fig. 141 shows the bad effect of holding the hand too low,—the edge would come in very slowly if you did not make the front corner of the hammer do more work. Continue the hammering in a spiral round and round the bowl to the edge, the distance between the coils of the spiral being rather less than the thickness of the hammer face, say ¼ inch. Before the hammering has reached the rim the latter will present a waved appearance, Figs. 143, 144. This is quite correct, but care must be taken to prevent any folding of the metal, for folds are extremely difficult to remove and, if allowed to remain, they develop later into cracks. To remove a pleat or deep wave remember to strike blows always at its narrow extremity—where it begins to rise above its surroundings. If you strike at the wider end you may, indeed, remove the fold, but your bowl is making no progress. You would only commence at the wide end if the metal had begun to form an actual pleat at the narrow end, which had to be got out at any cost. Anneal first.

When the hammering has reached to the edge of the disc, the metal will feel very hard and springy. It must be annealed before you go over it again. But if you wish the edge of the bowl, when completed, to be very thick and strong, it is well to put the work on a sandbag and hammer straight down on to its edge all the way round, before annealing. Do this after every course of raising, and by the time the bowl has been completed the edge of the metal will have grown considerably thicker. When you have given the metal its first course (of raising), its shape will be that of a shallow bowl about 9½ inches diameter and perhaps 1 inch deep, Fig. 146. Each successive course should increase its depth and decrease its diameter by about ⅜ inch. Beginners sometimes find considerable difficulty in inducing the bowl to become smaller at the top. They obtain a form something like Fig. 152. They have failed to keep the edge of the metal a sufficient distance above the top of the stake, and they have not seen to it that the front edge of the hammer face did its work properly by making the very definite angle, mentioned above, between that part of the metal which has been struck and that which has yet to be. The remedy for this state of things lies in keeping the elbow high and in listening for the sharp click which tells that the hammer has gone home. In some cases, when the metal is thin, for example, the other raising hammer (with face 1¼ by ⅛ inch) may be used to advantage. This hammer touches a smaller piece of metal at each blow, so the force applied is able to do its work more effectually. But progress is slower.

The different forms passed through in raising a bowl like Fig. 151 are shown in the series Figs. 145 to 151. It will be noticed that to reach a shape with a narrow mouth it is usual to shift the place from which raising is done from the bottom corner to B in Fig. 148. This will enable you to reach a form like Fig. 149, from which it is not difficult to produce the shape required. The raising should be continued until the neck of the bowl is rather less in diameter (⅛ inch or so) than the

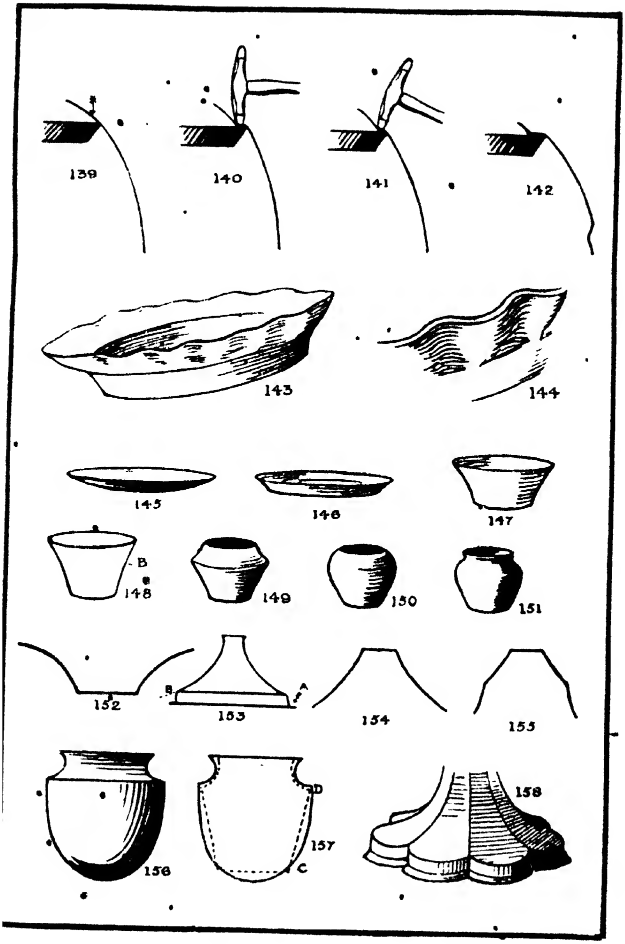
diameter actually required. Fig. 157 shows at C and D the points from which the raising would be done for a shape like Fig. 156.

To return to the work upon the cake stand, Fig. 165. The centre of the bowl may be hammered down to the correct curve with a round-faced hammer; the work resting on a sandbag. Should a bowl when being raised grow too deep, place it face downwards on the bench and tap it in all over with a flat-faced hammer, watching the curvature and taking care not to make any large dents. The pressure of the corner of the stake will have produced a projecting ridge at the scratched line mentioned above, or the corners B (Fig. 148), C and D (Fig. 157). The ridge or ridges should be removed also by hammering the work on a suitable stake. You generally raise a shape in straightish lines, filling out the curves when shaping and planishing. These processes come next. They go on more or less concurrently—bossing out, with rounded hammer or snarling iron, any part that is too hollow; and planishing, that is to say, hammering the work quite smooth all over—leaving a regular series of hammer marks everywhere. For the marks left by the raising hammer are irregular in position and uneven in size and depth. Anneal the work first. Find a stake which will fit the required curve. Hold the stake against the drawing to make sure. Probably it will fit only a part, so use the stake for that part of the work only, and another for the remainder. See that the stake is clean and smooth, rubbing it bright with emery paper if necessary. With the planishing hammer commence at the centre of the bowl and hammer out all the uneven marks. After doing a little piece, look inside. If the corresponding part there does not look smooth you must strike harder or use a heavier hammer. Go round and round in a long spiral from the centre to the rim, leaving a very regular series of hammer marks all the way. If the stake does not fit very well do not work straight round, but planish little patches about ¾ inch in diameter, each following on and blending with the others. Watch the outline and

remember that the work you are doing now will expand the bowl a little. For if you continue to strike hard on any place which is solidly supported underneath, the metal between hammer and stake must stretch, and, being stretched, must go somewhere, so your hammering will tend to raise a bump. Bearing this fact in mind, you will be able to shape your bowl as required. Should you wish to enlarge any part considerably you can boss it out with the snarling iron, as described later. Raising and planishing being completed, anneal, then work the flutes, as they are quite simple ones, by filling the bowl with pitch and putting the lines in with chasing tools. In any case, whether the bowl be plain or fluted, when the hammering is completed, if you find that the edge is not very true scratch a line round it with the compasses, just touching the lowest indentation in its edge. Then, with the open part of the bowl turned towards you, cut the edge true with the shears. Let them travel round the upper edge of the bowl towards your left hand. It is easier to cut in that direction. Then file the top of the bowl level and give it a rub on the flat stone to make quite true.

The raising of the foot, Fig. 153, must now be taken in hand, though many workers would carry on both bowl and foot alternately. The arm of the T-stake is too wide at the end to go inside the foot, so work should be commenced on a rod of iron about 1¼ inch in diameter. It may be held in the vice. Take no notice at present of the angle near the bottom of the foot, but raise the foot to the shape shown in the dotted line B, Fig. 153. It will not be necessary to thicken the edge of the metal by hammering, as you did for the bowl. The size of the top of the foot, where it is to join the bowl, must be gradually reduced from 1½ inch to the correct diameter,—about an inch at the top; the narrowest part of the stem being a little lower down It is not well to commence raising from so small a circle, for the smallness of the stake required, ¾ inch or so, makes the shape more difficult to raise, and the strain and wear on so small a circle are

rather severe. The point of the bickiron may be used for this part of the work when you have carried it as far as possible on the 1¼ inch iron rod, but it is well to see that the point is not so sharp as to cut the metal. Should the foot not be growing tall enough, use the rounded side of the raising hammer, but not quite close to the scratched circle, as the metal is apt to work thin there. The rounded side of the hammer stretches and therefore thins the metal, making taller the shape which is being raised. On the other hand, if the shape seems to be growing too tall, use the flat side of the hammer and hold the silver so that the point of the bickiron, or other tool upon which you are working, does not press against the top of the foot. If, however, this does not stop the growth, scratch another circle round the foot about half-way between the top and the rim. Then, on the T-stake, work from this line instead of from the smaller circle until you have reduced the rim to rather less (⅛ inch or so) than the required size. Your work will look like Fig. 155. Now continue the raising process, using the T-stake for the beginning of each course (near the rim), and the bickiron for that part of the foot which is too narrow for the T-stake to reach into. Place the T-stake and the bickiron with the point turned away from you, and raise from the rim to the top instead of from the top to the rim as at first. Still use the flat face of the hammer. Now that the rim is of the correct size there should be no difficulty in getting the top in also. When, by the eye and the callipers, you find that the shape is correct down to the little shoulder B, Fig. 153, planish down to there, and lightly scratch a circle to mark the corner. Then on the T-stake work down the lowest ¾ inch of the foot to the correct angle and planish that part also. The bottom edge of the foot may be turned outwards like A, Fig. 153, or a separate moulding soldered on as in Fig. 165. To do the former you must cut the lower edge of the foot true after the planishing of the surface below B has been completed. Then hold the foot upside down against the side and upper edge of some rectangular stake,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and tap over the little flange at the bottom. Then see that the bottom is quite level, so that it will stand on a piece of plate glass without rocking, yet touching all round. Afterwards file the edge.

When raising a tall, narrow shape you may find that the work has a tendency to lean over to one side. But if for each course you reverse the direction in which you rotate the silver while raising, the work will keep straight.

Should you wish to make a hexagonal foot, proceed as above, as far as the turning down of the last $\frac{3}{4}$ inch. In this case turn it down rather more steeply than the drawing shows, for the difficulty later will be to keep the base narrow enough. Anneal the work. Then divide the rim into six equal parts and draw lines very carefully to the top. These lines show where the corners are to come, so take great care to ensure their looking true to the eye as well as measuring truly. Cut out the little piece which forms the top of the foot. On any convenient stake flatten each of the six spaces with a mallet. Draw straight lines from corner to corner, crossing the lower part of each of the six spaces and formng a regular hexagon. Then, on a flat-sided stake, turn downwards all the metal which projects beyond the lines last drawn. Planish all over, taking great care to keep all the edges true. The bottom will now be uneven, and must be cut level. If the six sides of the foot, instead of being straight, are foiled like Fig. 158, then the parts below the angle B, Fig. 153, are made separately and soldered on, as described in Chapter XXVII. Solid drawn copper tube is sometimes used instead of sheet metal when a tall shape has to be made. The tube may, of course, be hammered and shaped just as the sheet metal can.

The raising of a shape like Fig. 156, proceeds in precisely the same way as that described for the bowl Figs. 145 to 151. Raise to the shape shown by the dotted lines. Shapes like Figs. 159 to 161 are formed similarly. Raise as shown by the dotted lines and afterwards fill out to the proper form; using a snarling iron where necessary. For a

description of this tool see page 127. Note in Figs. 159 and 161 that while the bowl is being raised its diameter is kept in every part a little less than that finally required. There is no difficulty in reducing the diameter at any point while the raising is in progress. When this is completed and the shaping and planishing have commenced, the whole work fills out a little. Any reduction now is rather more troublesome, for you have the planishing to do over again. The flutes in Fig. 160 are set out by scratching in the lines of the ridges, taking great care to get them true and regular. The hollows are then tapped in with collet hammers on to stakes Figs. 123, 124, fluted to the required shape. The flutes are thus planished on shaped stakes. By another method the bowl is filled with pitch and the flutes worked in with repoussé, modelling or chasing tools, see Chapter XIV. In modern commercial work the flutes would be struck out in dies. The lower bosses in Fig. 161 are worked out with the snarling iron, as described on page 127. The upper bosses can, however, be reached with a round-faced hammer, and may be bossed out on the lead cake. They are all finished, however, with the planishing hammer on suitably shaped stakes. Or the bowl may be filled with pitch and the shapes finished with chasing tools.

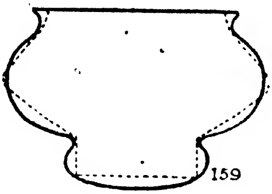
Bowls oval in plan, their long and short diameters having the ratio of about 3 to 2, Fig. 164, may be raised from circular pieces of metal. An elliptical line is scratched round the centre of the disc of metal (instead of a circular one as in the case of a round bowl). The metal near A B C and D E F will, in the course of raising, stretch more than the metal F A or C D. The reason is that on a curve of small radius (at the ends of the ellipse in this case) the metal gets hammered rather more severely, and naturally stretches to a corresponding degree. The unequal space between the edge of the metal and the scratched line is thus compensated for, and the bowl rises to an equal height all round. For an elliptical bowl, of which the ratio between the longer and

shorter curves is greater than 3 to 2, it is necessary to cut the metal elliptical also.

The lack of a sufficient variety of stakes will make the work more difficult, but if you have a new stake made when you find the need for it, or alter a useless shape into a good one, a good working set will soon be accumulated. Remember that you have a very useful set of small stakes in your hammers. Of these a dozen to twenty will be gradually accumulated.

At the Japanese exhibition held at the White City, Shepherd's Bush, in 1911, there were shown lions three feet high raised from one piece of sheet iron—without a join. They give an idea as to what can be done by careful work in this difficult material. Very fine pieces of raising may be seen in some of the mediæval morions and tilting helmets. These, of course, are of steel.

Although it is possible, it is not always desirable to make every hollow vessel in this manner. The soda-water bottle shape, Fig. 162, can be so produced, but it would be more reasonable to make it from a piece of solid drawn tube with a piece soldered on at the bottom. The narrow-mouthed square box, Fig. 163, could, if necessary, be raised in one piece, but it could be made much more easily if joins were permitted. Again, there is some difficulty in raising very small articles—they are so difficult to hold. Indeed, bowls of less than 1½ inch diameter may be struck in dies or between suitable shaped punches and a cake of lead or zinc. But with these exceptions, raising may be resorted to for the production of almost any shape.



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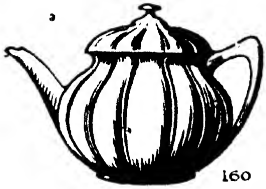

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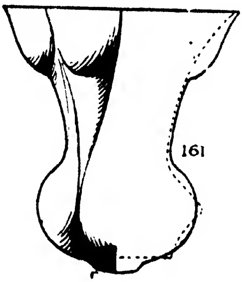

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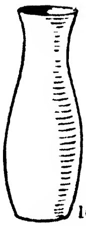

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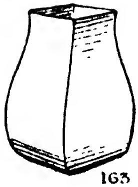

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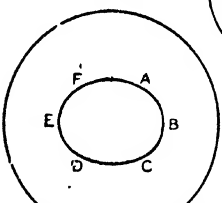

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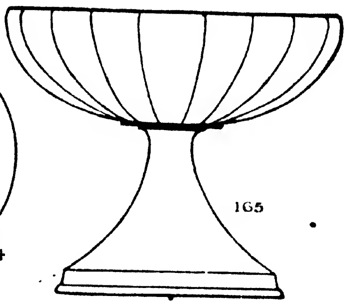

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CHAPTER XII

SPINNING

The lathe—The pattern or forme—The section chuck—Other chucks—Followers—Tools—Spinning—Lubricants.

THE bowls, stems and feet of cups, and hollow vessels of almost any form may be produced from discs of sheet metal by burnishing them into shape on a lathe. This process is known as spinning. It is applicable only to shapes which are circular in section: though the form of the work produced may, of course, be afterwards altered by the use of snarling irons, or by shaping and planishing it on suitable shapes. Thus, the general form of Fig. 161 could have been produced on the spinning lathe, the flutes or lobes being afterwards snarled and hammered out. But, primarily, spinning is employed for shapes which are circular in plan, whatever their profile may be. The process is in very general use among manufacturing silversmiths, to whom the ease with which a number of exactly similar copies of a shape may be produced is of importance. It has, however, little interest for the artist, for to him variety and a less mechanically smoothed surface naturally appeal.

The principal tools employed are the lathe, the pattern or forme, and the burnisher or spinning tool. We will look at these each in order and afterwards see how they are used.

Considerable speed being necessary, backgearing is not required in the spinning lathe. Almost any single-geared lathe which is large enough may be used. Small work may be spun with a foot lathe, but, as in wood-turning, any diameter greater than about five or six inches means very hard work unless you have power. A speed of from 800 to 1200 revolutions per minute is necessary for the metals with

which we are dealing. The thicker the metal, the less the speed required. The rest employed is like the ordinary T-rest of the wood-turner, Fig. 175. It has, however, a row of holes drilled in its top edge. Into any conveniently placed one of which a stout steel peg, known as the "pin," is dropped. Its use is explained below. The tailstock is similar to that used for turning, but it is often fitted with a revolving centre. In this case the centre, which is not tapered, rests against one or two hardened steel buttons which take up most of the friction, Fig. 166.

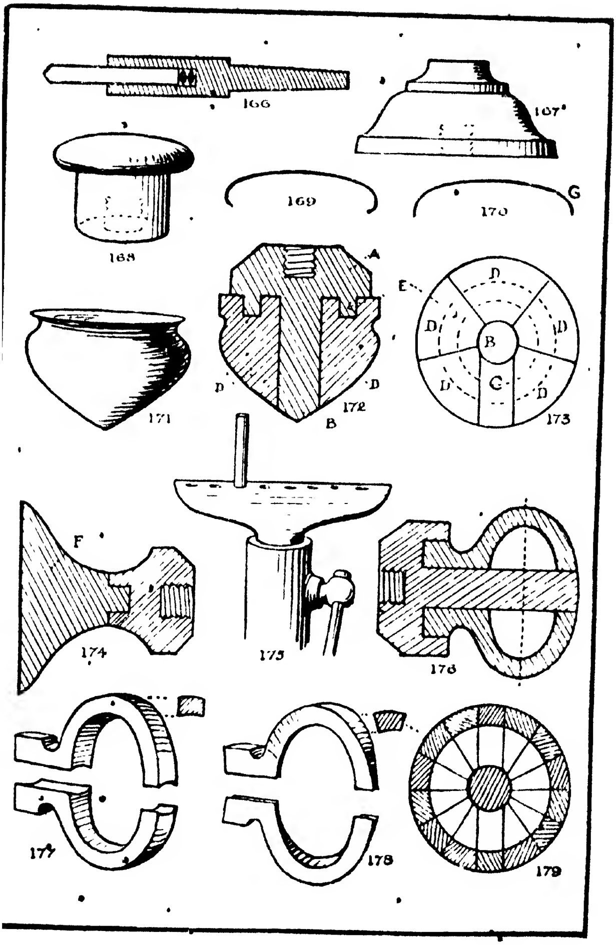
The forme, pattern or chuck upon which the metal is spun plays a very important part in the work. It is a block of wood or metal of the exact shape of the bowl required; though it is made smaller than the design by just the thickness of the metal employed for the bowl. When the shape of the bowl is such that the pattern can be withdrawn from it when the spinning is completed, Fig. 167 for example, the pattern is made in one piece. But if the shape would not allow of this, and you do not wish to destroy the pattern after it has done its work, a section chuck must be employed instead. The forme or pattern is generally of well-dried maple. The block from which it is made is bored and tapped to fit the nose of the lathe, and then turned to fit a templet which has been set out from the drawing. Due allowance is made for the thickness of the metal which is to be used for the bowl.

For a shape like Fig. 171 a sectional chuck would be used. It would be made as shown in section in Fig. 172. The part A is fitted to the nose of the lathe by the screw shown in the drawing and extends as a thick parallel-sided pin, B, to the bottom of the bowl. Round it, completing the shape of the bowl, are a number of movable pieces, D, Figs. 172, 173. At least one of these, a "key" section, C, Fig. 173, has parallel sides. It is always rather thinner than the pin or core of the chuck B. When a bowl has been spun on to the chuck, the bowl and the movable sections are together pulled lengthwise from B, the core of the chuck. The key piece

may then be wriggled free. It has room to shift now that the core has been removed. The remaining sections come out easily, and are replaced at once round the core, and the chuck is ready for the next bowl. Sometimes patterns are made with more than one key piece, but unless at least one is provided the radial pieces could not be removed. The projecting ring E on piece A fits into a groove in the movable sections and keeps them together. The shape, or "stock," or "shell," as the bowl is sometimes called, would be spun up as far as possible on another (a simple pattern), before being transferred to the section chucked for completion. Another form of section chuck suitable for a deeper bowl is shown in Figs. 176 to 179. Yet another kind, known as a plug chuck, is shown in Fig. 174. It is used for shapes which are constricted in the middle and open at each end. The bottom of the shape spun on Fig. 174, must, of course, be cut out before the movable section F of the chuck can be removed. A shape like this would, however, be more easily spun from a tapered tube than from a disc.

Yet another kind is the nailhead chuck, Fig. 168. It is made from a hard wood, such as boxwood. This chuck is used for turning inwards the lip of any small bowl or dish. It thus saves the expense of making a sectional chuck for a shape like Fig. 169. The diameter of the chuck must be less than the mouth of the complete bowl. The chuck is rubbed with powdered pumice and water to make it grip the work. The latter, which has already been spun as far as possible on another chuck, is slipped over the nailhead and kept in position with the finger. With a little trouble the edge G, Fig. 170. may be worked round to the curve shown in Fig. 169.

A bowl such as Fig. 180 can be made without the aid of a section chuck. It is spun on an ordinary pattern which fits it from the bottom to as far as the angle H. By the time that the bowl has been spun thus far the rim will have taken a curve something like that shown by N, Fig. 188. A hooked tool K, Figs. 181, 182, is now clamped firmly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to the rest or to the lathe-bed. Seen from above the rounded end of the tool "takes up" or continues the curve of the pattern beyond the corner H. The tool, of course, does not rotate, as the pattern does, but it remains permanently near the corner H, and so supports the bowl against the pressure of the spinning tool. The bowl can, therefore, be spun to the required shape just as though it were on a section chuck. In some cases a hole is drilled through the shank of the tool at J, and the tool slipped over an extra pin in the T-rest. It may be held in place by an assistant.

A shape like Fig. 167, say for the base of a cup, can be spun without difficulty. Even if the mouldings are undercut, as in Fig. 183, it would not be impossible. If the pattern were required again it would be necessary to cut away first those parts of it which would bind when the metal was spun over them. The metal at those places would be spun without support, "in the air" as it is called.

The decoration of a bellows pipe, such as Fig. 184, can be effected by holding the tapering pipe or tube between centres or arbors, and spinning it to shape without any further support inside. The baluster stem of a cup may be spun in the same way. But it is better to turn a wooden pattern to the required shape first; to slip the tube from which the stem is to be spun over the wooden pattern, and then to spin the metal hard down against the wood. The latter may be burnt out afterwards.

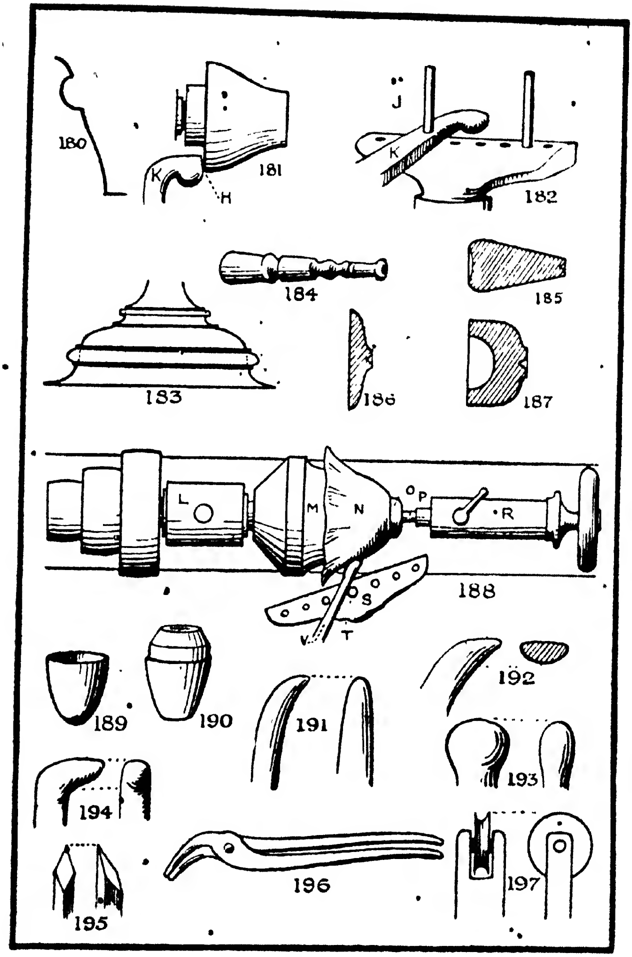
The disc of metal from which a bowl is spun is kept in position against the forme by a small block of wood known as the "follower." The latter in its turn is supported by the revolving centre of the tailstock. This is shown in Fig. 188, where L is the head of the lathe, M the forme, N the blank or disc of metal which is to being spun, O the follower, P the revolving centre, R the tailstock, S the rest, T the pin, and V the tool. Followers are made in different shapes with flat or hollow faces, Figs. 185 to 187. The important thing to notice about them is that as large a follower as possible is always chosen. With a large follower the disc of metal

is not so likely to jam and stop rotating; for the grip of a large follower is so much greater than that of a small one. Nevertheless, some difficulty is frequently met with in spinning a shape like No. 189 as so small a part of the pattern would be in contact with the disc of metal at first. Spinners frequently flatten the bottom of the forme like Fig. 190, just to give a better grip. They also rub pitch or powdered pumice on it for the same reason. Another way to obtain the same result is to raise a good-sized shallow bump in the centre of the disc of metal to be spun. This bump may be pressed almost flat again between the forme and the flat follower by screwing the tailstock tightly, and the extra pressure obtained in this way will naturally give a better grip.

The tools are longer and heavier than those used by wood-turners. Including handle, they measure from two to three feet in length, and may be from half an inch to an inch in thickness. They are forged from tool steel, hardened, tempered, and polished very brightly. They are made in a number of shapes, but that shown in Fig. 191 is perhaps the most convenient for general use. It, like all spinning tools, has a smooth, highly polished surface with no sharp angles or corners which might cut or tear the metal. Fig. 192 is a similar tool but with flat face for smoothing up. Fig. 193 is a ball tool which goes into curves rather well. Fig. 194 is a hook tool useful for a variety of curves. Another tool is a pair of long handled pliers, the jaws of which have been bent round in a curve, Fig. 196. The inner edges of the jaws are carefully rounded and polished. The edge of the rotating disc may be seized lightly with the tool and bent round in a quick curve to form a bead, the shape being completed with the aid of a hollow-faced wheel tool, Fig. 197, which is known as the beading tool. The diamond-point, Fig. 195, made from a square bar of steel, is useful for cutting the edges of the work true. It is the ordinary metal-turner's hand tool. If the metal which is being spun is thick enough shallow mouldings and lines are sometimes turned in it, and

its surface smoothed up with a sharp-edged turning tool. The work may also be smoothed with emery cloth and polished, while still on the forme. The backstick is a piece of hard wood which is held in the left hand against the reverse side of the rotating disc when the spinning tool is working it into shape. The backstick is of great assistance in keeping the edge of the disc from wobbling or getting into pleats. It should follow the tool about as it moves.

To spin a bowl, Fig. 189 for instance. First turn in the lathe a forme of the right shape, but flattened at the bottom a little to give a better grip, Fig. 190. Rub a little pitch or resin on the flat part of the pattern for the same reason. Take a disc of metal of suitable size and grip it between the flattened end of the forme and a suitable follower; centre the disc by holding a piece of hard wood against it as it rotates. When true, screw up the tailstock tightly and clamp it. See that the centre is kept well oiled. Slide the rest to a convenient position and clamp it also. Take a tool, Fig. 191, and hold it to the left side of the pin in the rest, against the metal disc close to the follower. Starting from that place, slowly and very firmly press against the disc as it rotates, stroking it from near the centre to the edge again and again. Try to force it against the forme. Considerable pressure is necessary in spite of the great leverage you have against the pin. You will have no difficulty in pressing the metal in near the centre, but the rim will give you some trouble. As in raising, the most difficult part of the work consists in getting the edge to come in, and in preventing it from becoming waved or pleated. As the tool approaches the edge little pleats will begin to form, and they become largish waves at last. If you press hard the disc will just go out of shape, and buckle or wave, or even pleat badly. To prevent this you must steady the edge of the metal by holding the backstick against it. This will do something to counteract the pressure of the tool on the outer surface of the bowl, and it will keep the edge true. The secret of success in spinning consists in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catching the pleats when and where they are small, just as they begin to rise above the surface of the metal. Press them out there. If, however, they will not disappear, and the work is getting uneven, remove it from the lathe. It has got hard; so anneal it and then hammer it true on a stake. Whenever the work becomes hard and springy it must be annealed. When part of the metal has been spun right down on to the pattern, take the diamond-tool and turn the edge true. Be careful how you hold this tool, for if held carelessly it is liable to run in and mark your work badly. It is well always to keep the edge of the disc trued up in this way for it will spin better. When the shape is correct, slip the work off the forme and boss out the bottom with a mallet on a sandbag. It will require but little planishing. Of course, if the bottom of the bowl is not very pointed there will be no need to flatten the forme as described here.

To lessen the friction it is necessary to lubricate the work well. Use a mixture of tallow and oil. Keep it in a covered pot and dip the tool into it from time to time. Silver and gold can be spun with oil alone, but for brass tallow is almost essential, though beeswax, or soap, is sometimes used instead.

CHAPTER XIII

REPOUSSÉ WORK

Materials and tools – Pitch—Lead or zinc—Board work—Composition of pitch— Removing pitch—Repoussé and chasing tools—Snarling irons.

REPOUSSÉ is a general term to describe ornamental work produced by modelling sheet metal with hammer and punches. It differs from cast ornament and from stamped work both in design and in treatment. For upon the visible traces of its method of production a considerable portion of the charm of repoussé work depends. The thoughts which the craftsman was able to put into his work supply the remainder. The surface of the work should be bent to and fro to catch the light at different angles. Some parts of the ornament should be lower in relief than the rest, and should fade away into the background. The thing to avoid in this and all other relief work, is the effect of ornament which has been made from a different piece of metal and has been stuck on to the background. It should be obviously of one piece, but with surfaces tilted about to play with the light, an ornamentation of the metal rather than a decoration applied to it. Strictly speaking repoussé is that part of the work which is done from the reverse side of the metal —the bossing up of lines or patterns from the back. Chasing is the part which is done from the front. The term chasing is also applied to the touching up of cast work.

When a raised pattern is to be produced on the surface of the work, the metal is placed face downward on a pad of some material which will yield sufficiently to the force of the blows given, but which will at the same time support the metal near by, and prevent it from being disturbed. For this purpose it is necessary that the supporting material shall be in continuous contact with the underside (really

the face) of the work. Now the best material for this purpose is pitch, prepared as described below. Pitch being an adhesive material, too much so sometimes, it will remain in contact with the metal, even after a considerable amount of hammering; and owing to the even support given to the metal a sharp impression will be made of the shape of any tool used, especially if the pitch is allowed to get cool and hard. A tool, however, is generally moved about while being struck by the hammer, so that an impression of its exact shape is rarely visible.

To obtain any considerable amount of relief it is necessary to work while the pitch is warm and soft. It sets fairly rapidly. A support of lead, tin or zinc, will give a clear, sharp impression, and these materials have the advantage of being clean to work with. Not, however, being of an adhesive nature, they do not keep in close contact with the work. So, after a small amount of hammering, some parts of the metal will be found to be unsupported, and therefore unsafe to work upon. A cake of one of these metals is most valuable as a backing where a small amount of bossing up is required, as in knocking up little discs or leaves. Care must, however, be taken to remove any particles of zinc or tin or lead, which may have transferred themselves to the work, for they would cause serious damage if it had to be heated afterwards. Linoleum and wood are two other materials which can be used as a backing, but pitch is the best all-round material.

Patterns in relief can be, and often are, obtained by beating down the background of the design from the front, instead of by raising the ornament above the level of the background by working on the underside of the metal.

Among the various ways of holding the metal the simplest is that of fastening it to a board with nails. This method is only suitable when outline work, or very low relief is required, as on a tea-tray. It has the advantage, which pitch has not, of being quite clean to use. The best nails are 1-inch oval sprigs. They are driven into the wood, at intervals of 2 to 3 inches, all round the sheet of metal to be

worked upon. The nails are not placed close up to the edge of the metal, but about ¼ inch beyond it. They are driven about ⅝ inch into the wood, the remaining portion is then knocked over sideways on to the metal. The nails, being oval in section, bend easily, but care should be taken that their heads are not hammered into the metal, for the little marks they make are difficult to get rid of. In tracing a large piece of work, the central parts should be done first. When the work has proceeded for a while it will be found that, owing to the stretching of the metal, parts of it have risen from the board. These must be tapped down till the metal again rests on the wood, it being almost impossible to work on the metal where it is not firmly supported. It will be found that the most convenient tools for this purpose are a mallet or a levelling tool—a piece of boxwood ¾ inch square by 4 inches long, used as a repoussé tool. In this and in nearly every other case where tools are used to drive sheet metal flat, the section of the tool, where it touches the metal, should be flat with rounded edges and corners, Fig. 198. The reason for this rule is, that when the force of the blow carries forward that part of the metal with which it comes in contact—disturbing the adjacent metal very little—a square-edged tool would leave a sharply defined mark, or cut, round its outline. The tool with rounded edges, however, would bend the metal there without cutting it.

When the outlining is completed the work can be backgrounded, if necessary, where it is. In this part of the work it is well to commence near the traced lines and work towards the more open parts of the background, and not from the middle of the open spaces towards the pattern. For by working in the last-named direction a little hill of metal will be driven up near the traced line and this will be difficult to get rid of. Backgrounding is done with levelling or matt tools, and the hammering thus given to the background drives the pattern up in relief. The amount of relief produced in this way varies with the thickness of the metal. For a tray about 20 inches by 9, copper size 10 on the metal gauge should be used, and the relief would be

about $\frac{1}{16}$ inch. For a tray 24 inches across, size 12, the relief would be rather less. Size 15 is too thick for it to be possible to produce much relief by this method. By the time that the backgrounding is completed, the whole work will be found to have stretched, perhaps $\frac{1}{4}$ inch to the foot. Hence the necessity of placing the nails in the first instance at some distance from the edge of the metal. Woods with a strong grain, such as oak, pitch-pine, etc., are not suitable for repoussé boards, as after some use the harder part of the grain of the wood is left standing in ridges. Among the tools required for repoussé work will be—

1. A board of some hard, close-grained wood, such as sycamore, measuring say, 20 by 12 by 1 inch, for use as above described.

As a ground, pitch allows of far greater possibilities in the way of relief and texture than other materials do. The pitch used is that known as Stockholm, or Swedish, pitch. It is dark-brown in colour, and can be obtained from any dealer in jewellers' requisites. Pitch is too brittle to use alone, it must be mixed with some other substance to make it tougher. For this purpose tallow and plaster of Paris, mason's dust, bathbrick dust or resin, may be used. Take—

(i)	Pitch	10 lb.
	Brickdust	20 „
	Resin	4 „
	Tallow	2 „

(ii)	Pitch	6 parts,
	Brickdust	8 „
	Resin	1 part,
	Linseed oil	1 „

or—

(iii)	Pitch	14 lb.
	Resin	14 „
	Plaster of Paris or brickdust	7 „
	Tallow	8 oz.

Melt the pitch, or the pitch and resin in an iron pan. When quite liquid add the plaster of Paris or brickdust by handfuls, stirring well all the while. Put in the tallow last. Its effect is to soften the composition, so rather more tallow may be required in cold than in warm weather. Linseed oil is sometimes used instead.

2. A pitch board. This is a rough wooden tray 1 inch deep, filled with pitch. It should be made as large as you are ever likely to require. To fasten a piece of work upon it, warm the surface of the pitch with a blowpipe, taking care not to set it alight. For that would be dangerous, and the cinders of burnt pitch act as air-bubbles, so you do not get an even support for the metal. With blowpipe and a rod or spatula level the surface sufficiently, removing any burnt pieces. Then lay the metal upon the pitch and press it down with the handle of a hammer. Place weights on it until it has set. Should any bubbles be left under the metal, they can be located by the hollow sound which the metal over them will give when tapped. Heat any such place with the blowpipe, or by placing a piece of red-hot iron on it, and press down again.

To remove the work from pitch. If the pitch is quite hard a repoussé tool driven under the edge of the metal, between it and the pitch, will often give sufficient leverage to crack the metal off. But if the pitch still holds, or there is any danger of injury to the work, it is safer to warm the metal with the blowpipe. The heat melts the pitch in contact with it, and will allow the work to be lifted off with pliers. The metal is then made a little hotter, though not hot enough to set the pitch alight, but just enough to induce the pitch still adhering to it to flow easily. The work can now be wiped clean with cotton waste or a brush dipped in paraffin. Paraffin readily dissolves partially melted pitch. But should the pitch get chilled before it can be all removed from the metal, it may be necessary to warm the latter again. Care must be taken in this case not to set everything alight. Burnt pitch is difficult to remove.

indeed, the simplest way to get rid of it is to anneal the work thoroughly and plunge it into water. It may be necessary to do this twice to remove all traces of the burnt matter. Molten pitch is very sticky, but it can be handled with impunity, when it is not too hot, if the hands are kept wet.

3. A pitch bowl and ring, Fig. 199. The bowl is hemispherical, of cast-iron, 9 inches in diameter and about ½ inch thick. Filled with pitch it weighs about 20 lb. The weight is of importance, for if the bowl is much lighter it will be likely to dance about when you work on it. It stands on a ring, which may be of leather or of coiled rope. The bowl can be turned about or tilted to any angle as the work proceeds, all the while standing firmly in its ring.

4. Two hammers. One weighing about 16 oz., this may be of almost any shape if it has a flat face. It is used with the larger repoussé tools. A light hammer is unsuited for such work. The second hammer is the chasing hammer shown in Fig. 200. The head weighs 3 or 4 oz., and the handle is about 9 inches long. Its rounded end makes it easy to hold, and use. A wooden mallet can be used instead and it makes less noise.

5. Punches and chasing tools of various shapes. Although a considerable amount of ornamental work could be done with a couple of punches—a tracer and a backgrounding tool—yet one would soon find their limitations. Fifty to seventy repoussé and chasing tools make a useful set, though a professional worker may have several thousand. Out of these he has perhaps a dozen favourites. The tools are all about 4 inches long, but they vary in thickness. The smaller ones are generally forged thicker in the middle of their length, as they are then easier to hold. Tools with sharp angles or rings on the shank hurt the fingers, so they should be avoided. It is better and cheaper for the worker to shape the points of his tools as he may need them; for the tools he can buy are rarely the exact shape that he requires. Unfinished tools, called blanks, can be bought

ready forged. They only require the points to be shaped and hardened, and are then ready for use. The tools being all very much alike except at the point, the description given below refers to that part of them which actually touches the work. Although no two in a set are alike, the tools fall naturally into a few groups, known by the following names. Tracers. Bossing, cushion, modelling and chasing tools. Matts, freezers and liners. Ring, number and letter-punches.

Tracers are like rather blunt chisels, and are used chiefly for outlining. Their working edges vary from about $\frac{1}{100}$ inch in thickness by $\frac{1}{16}$ inch long, to perhaps $\frac{1}{8}$ inch wide by $\frac{3}{4}$ inch long, Figs. 201 to 204. The last one is curved as shown in the section. A very useful size is about $\frac{1}{64}$ inch thick by $\frac{1}{8}$ inch long.

Tracers and all the other tools are held in the same way—between the thumb and the first two fingers of the left hand. The third, and sometimes the fourth, fingers rest on the work to steady the hand, Fig. 215. The tracer is held nearly perpendicularly, but leaning back a little from the direction in which it is to travel. The front corner is thus lifted a little above the metal. If a blow is now struck with the hammer on the upper end of the tool, the corner of the tracer, known as the heel, will be driven into the metal. The tool will, at the same time, move forward slightly. The blow is repeated again and again, the edge of the tool slowly sliding forward and cutting itself a channel in the metal. Some of the material displaced goes to form a little ridge on either side of the traced line. Some of it, if the metal be not too thick, is driven up in a ridge on the underside of the metal. Some difficulty may be found at first in getting a tracer to work properly. If held too nearly perpendicular it will not move along at all, but will dig into, and perhaps cut through, the metal. If held at too great a slope, the point will slide away, making merely a scratch on the surface. The correct angle to hold it can be ascertained only by trial, and it varies with different tracers. In making

curves of small radius it is necessary to tilt the tracer back further than usual, so that only the heel touches the metal; for if held at the usual angle, it would be likely to make a series of tangential marks round the outside of the curve. The tracer is much more likely to slip away when so held, so it must be gripped very firmly. Curved tracers, Fig. 204, are sometimes used, but with a little practice curves of any radius can be, and generally are, worked with a straight tracer. At whatever angle the tracer may be held to the metal, the blow from the hammer should always fall in a direct line with the axis of the tool. Beginners frequently make the mistake of striking the head of the tool at an angle instead of fairly on the top—with surprising results. If the point of the tracer is dipped occasionally in oil it will move more freely. The edge of the tracer which is to touch the work is not invariably made just at right angles to the shank of the tool, as in the case of an ordinary chisel. It may be sloped like a skew chisel, and vary as much as 20° from a right angle, Fig. 203. If made so, it will travel easier. The heel of the tracer is sometimes rounded off a little. The bottom of the groove made in the metal should not show "stitches," it should be nearly smooth.

Bossing and cushion tools, Figs. 209 to 214, are made in various shapes:—round, tapering, square or oblong, but they are all alike in this—their sharp edges are rounded off. For the purpose of this group of tools is to drive the metal up in bumps or ridges, and any sharp corners on the tool would be likely to cut or tear the work. Bossing and cushion tools are therefore more or less circular in section at their working ends. Modelling and chasing tools, Figs. 205 to 208, on the other hand, being used on the front surface of the work, are, as a rule, much flatter. Many of them are quite flat at the point, though sometimes the extreme edges are rounded off. It will be clear, however, that to obtain a rounded or a level surface on the work, one would hardly care to use a very rounded tool. It is on this very point that so many ready-made tools fail,

they are not flat enough. The ideal tool is quite flat in the centre, though it may, perhaps, have its corners and edges rounded off a little, as in Fig. 198.

Lining, freezing and matting tools are used to give variety of texture to the work. Liners have a number of shallow lines, or grooves, across them; the others are hatched in different manners. The function of this whole group of tools has been much abused. Texture is often relied upon to produce changes of light and shade which should have been caused by changes of plane. It is better to produce the desired effect by modelling the surface than by altering its texture. These tools are useful in touching up cast work. A very finely grained matt tool can be made by nicking a rod of hard steel all round, then breaking a piece off and using the broken end.

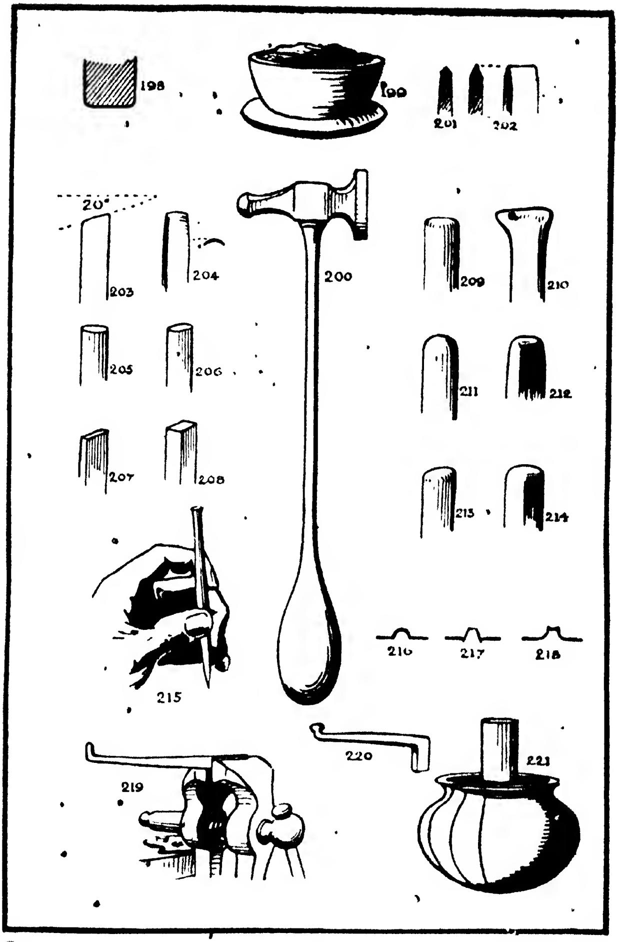
Ring tools make a circular mark, as their name implies. Number and letter punches are made in sets. The letters or figures are reversed, like type, if they are to be used on the surface of the work; but are not reversed when the punches are to be used on the underside.

Tools for backgrounding or for producing an "all over" texture are so held that they can be moved about freely just above the surface of the metal, the force of the hammer blows bringing them into contact. The work can be done thus much quicker than if the tool is brought to rest upon the surface of the metal, and the blow then given.

6. One or two snarling irons, Figs. 219, 220. These are rods of iron perhaps a foot long by about ½ inch square. One extremity is held in the vice, and the other ends in a rounded knob set at right angles to the axis of the rod. These tools are often made Z-shape, as shown in Fig. 220. They are used to produce bumps or bosses on the outside of tubes, bowls or other vessels which are too narrow in the mouth to allow the insertion of a hammer, or repoussé tool, for that purpose. One end of the tool being in the vice, the bowl or other work is so held that the knob on the tool is pressed firmly against the underside of the place

where the boss is to be produced. A sharp blow is now given to that part of the snarling iron which is near the vice. The rebound from the blow causes the knob to strike sharply against the metal opposite to it. The blow is repeated again and again, until a sufficiently large bump has been produced on the work. It may be necessary to anneal the work should it get hard before this result is attained. The pattern, having been roughly bossed up in this manner, can be finished from the front with chasing tools. An iron bar should be used to strike the snarling iron. It is easier to manage than a hammer.

7. Two or three cakes of zinc, tin or lead, weighing 3 to 10 lb., for use as described above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CHAPTER XIV

REPOUSSÉ WORK (*continued*)

Transferring the design—Lettering—Patterns on bowls—Work in the round.

To transfer a design to sheet metal the simplest method is that of tracing it with carbon paper. Part of a knitting-needle set into a wooden handle, as the lead in a pencil, makes a good stylus. The point of the needle should be ground quite smooth and round. When buying carbon paper see that the marks it will make on metal do not rub out very easily. Paper which is prepared on one side only should be chosen. To a convex surface, such as the side of a bowl, or to any domed-up piece of metal it is nearly impossible to transfer a design in the manner just described. It should be drawn freehand in pencil, the proportions being checked by measurement with dividers. To make corrections in the drawing, first rub out the part that is wrong. This is best done by fine emery paper used with a circular stroke, then re-draw with pencil or ink. Ink-lines may be trued up with the point of a knife. Another method is that of laying the design upon the metal, and then lightly pricking out the principal masses with a pointed punch. The little marks showing through on the other side of the metal will serve as guides for knocking up the parts in relief.

Inscriptions may be worked from either the back or the front of the metal, or by a combination of the two processes. It all depends on the form and section of the letter which you wish to use. A letter which is round-topped in section, Fig. 216, can be worked entirely from the back. For a square-topped letter, Fig. 217, some chasing on the front may be necessary, as also for a form such as Fig. 218, where the

top of the letter is hollowed. It is important to remembe that when inscriptions are worked from the back alone each individual letter will work out taller and wider thai the drawing, to the extent of about double the thicknes of the sheet of metal from which it is beaten. The letter in the inscription will therefore appear to be crowded close together than in the design. When working from th underside of the metal allowance must therefore be mad for this thickening of the letters, by tracing them, to th extent indicated, slenderer and shorter than they are showr in the drawing. They will then work out the right size in front. When letters are outlined from the front, of course no such allowance has to be made. Perhaps it is hardly necessary to point out that inscriptions must be reversed, right and left, on the back of the metal if they are to come out the right way round in front.

When letters are to be outlined from the front, the metal may be either fastened down on wood with nails, or the work may be done on pitch. The outlining is done with a tracer. The metal is then turned face downwards on to the pitch board. The work done with the tracer in front will show through on the back of the metal as a ridge round the outline of the letters. This will serve as a guide for the embossing. Each letter is now knocked up, piece by piece, first with a tool shaped like Fig. 214 and afterwards with others like Figs. 205 to 208. Should a square-topped letter be intended, a traced line is put in from the back a little within the ridge just mentioned. This traced line will outline the top of the letter. All the metal within it must now be driven down to the level of the deepest part of the line. Before all the letters have been embossed the edges of the sheet of metal will probably have risen high enough to break loose from the pitch. They must be kept down with heavy weights. Care must be taken to work on no parts of the metal which are insufficiently supported. Should any such be found, the metal must be warmed and pressed down into contact with the pitch before the work can proceed. When all the

letters have been worked, remove the metal from the pitch and clean it as described above. The driving up of the letters will be found to have forced the background forward a little also. Lay the work on the bench or on a large flat stake and go over it all carefully with a mallet, straightening the sheet and driving the letters bodily a little towards the background. Owing to the hammering which they have already received, the letters will be harder than the background, so if treated carefully they will not be injured. Put the work on the pitch board again and finish up the lettering from the back. Remove it from the pitch, clean and level it as before. If the letters are now to be chased from the front, turn the work face downwards on the bench and fill all the hollows at the back of the letters with broken pieces of pitch. Heat the work until the pitch runs in and fills up all the hollows. Let it cool a little. Warm the pitch on the board with the blowpipe. Lift the work and put it face upwards on the pitch board, and leave it under weights until cool. It can now be tooled over as required.

To work a pattern on a bowl, first anneal the work, then fill it with pitch, inserting at the same time a piece of wood 1½ inch diameter (not less), and long enough to project several inches above the top of the bowl, Fig. 221. When the pitch has set, grip the projecting piece of wood in the vice, tilting it to any convenient angle, and the work can proceed. Another method is to fill the work with pitch and to lay it on its side on a sandbag. A stirrup of rope, passing over the bowl, through holes in the bench to the foot can be used to steady the work while the chasing proceeds. When the chasing has been carried far enough, warm the work with the blowpipe until the pitch can be turned out. If the metal is hard anneal it again. Should the mouth of the bowl be large enough to allow the use of repoussé tools inside, put the side of the bowl on to a pitch board and boss up the pattern from the inside, turning the bowl on the pitch board when necessary. If the mouth of the bowl is too small, boss up the pattern with snarling irons. When sufficient relief

has been obtained, anneal the work, refill with pitch as before, and finish from the outside.

Repoussé work has sometimes to be done almost in the round. The metal is first raised to about the desired relief either by bossing it up from the back with round-faced hammers or punches; or by raising the shape with a hammer on a stake, just as a bowl is formed; or by a combination of these two methods. The great difficulty is to keep the metal approximately the same thickness all over. It is well to work alternately from the front and back, gradually arriving at the highest relief and the lowest undercutting. Remember to anneal the work whenever it gets at all hard. Any cracks must be joined up with hard solder (unless you are working on a metal which will not allow of its use). When the right relief has been arrived at, anneal the work, fill the hollow with broken pieces of pitch and melt them in, taking great care to leave no bubbles. Then put the work on the pitch bowl. At this stage the design will be represented by an unevenly bossed up sheet of metal, a little larger in every direction than the shape desired, yet suggesting it much as the dust-sheet covering a statue reveals the true form underneath. Now draw the figure or design in very carefully in pencil or ink, and go ahead with your chasing tools. The first thing to attend to is to get all the big planes in their right places. For example, suppose that you are doing a head in profile. Now, no amount of beautiful work on the nose and mouth will be of any use if these parts are left the same height above the background as, say, the ear or the hair. They should be in lower relief. They must go down or the ear and hair must come up, and in like manner through the whole work the planes must be made correct. It is only when this has been done, and work looks well from the side view as well as from the front, that the finer details should be put in. Whenever the metal gets hard in the process of working, it must be taken off the pitch, cleaned, annealed and filled with pitch again, before the work can proceed,—otherwise it may crack badly.

CHAPTER XV

MOULDINGS

Folded edges—Wired edges—The drawswage—Making the dies—The drawbench—Swaged mouldings—Turned mouldings—Bending strip metal—Running plaster mouldings for casting.

PERHAPS the simplest form of moulding is that produced at the edge of a piece of sheet metal by folding it upon itself, or over a wire. The turned-down piece thus forms a little border or moulding, Fig. 223. The tool used for this folding of the edge is known as a "turning-over tool," Fig. 222. It just a flat piece of steel or iron measuring perhaps 5 inches by 2 inches by $\frac{3}{16}$ inch. An old plane iron can be turned into a very good one.. Soften it in the fire. Leave the end nearly sharp, bevel one long edge to rather less than $\frac{1}{8}$ inch thick, and file all the sharp edges off it and off the other long edge, which should be left, however, to the full, $\frac{3}{16}$ inch, thickness. The top of the iron, where the hammer used to strike it, should be rounded for use on curves, and all its sharp edges smoothed off. If a moulding like Fig. 223 is required, put the tool in the vice with its thin end upwards. About half an inch of the tool must project above the jaws of the vice. If more, the tool will vibrate more than you wish. Mark a line on the metal parallel to its edge, either by ruling it with a straight-edge, or, if you are sure of the truth of the edge of the metal, by setting a pair of dividers to the correct span and running it along the edge. One leg of the dividers sliding along on the bench against the edge of the metal, the other resting on and marking its surface, see Fig. 18, page 49. Of course, curves may be drawn in the same

way. Hold the metal so that the scratched line comes over the turning-over tool and tap the edge down with a mallet, or with a hammer which has no sharp edges to its face. Remember that whenever metal is bent with a hammer, the face of the tool should have rounded edges, otherwise it will mark the metal badly. The edge of the metal should be tapped over the tool until it is bent to about right angles to its original position. Then lay the work on the bench with the bent edge of the metal sticking up. Carefully and evenly tap the edge down on to the sheet, making sure as you do so that an equal amount is turned over all along, and that the folded edge makes a true line, not a waved one. To do this neatly requires a good deal of care, though the work itself is very simple.

If it should be necessary to hide the actual edge of the metal you may fold the edge in on the side which will not show on the completed article. When the edge has been tapped down evenly, place the work with the folded piece downwards on a flat stake. Take the hammer and a piece of boxwood shaped like a square-ended repoussé tool, its sharp corners having been removed, and tap down to the stake that part of the metal which is a little further from the folded edge than the turned-in part extends to, Figs. 224, 225. The double thickness at the edge will become a moulding, raised a little above the surface. If a large moulding is required the metal may be folded over a wire, which may itself be of almost any section. To cover a wire properly it is very important that the correct amount of metal should be allowed for the purpose. Too much is worse than too little, for the superfluous amount crumples up untidily, and is very difficult to remove. First see that the edge of the metal is true. Then make a pencil mark parallel to it three times the diameter of the wire distant. Thus, for a quarter inch wire mark the line ¾ inch from the edge. Put the turning-over tool in the vice with its rounded edge upwards, and turn down the edge of the metal from the mark. Tap the metal well over the tool, so as to form as

much as possible of the hollow to receive the wire. But give it as few blows as will do the work, for much hammering would stretch the edge of the metal, and you do not wish that. Now rest the metal on a flat stake, the bench, or a smooth cake of lead, and hold the wire into the hollow with pliers while you tap the edge of the metal right round it. Cut the wire only when it is nearly all covered in, for the exact length can then be easily decided,—not an easy matter otherwise, on a curve. See that you leave no sharp edges when you cut the wire, or they may work their way through the metal later on. The wired edge may be brought forward in the same way as the folded one, Fig. 226. Or the work may be held face downwards on a stake with the wire and folded edge of the metal on top, the wire over-hanging the edge of the stake as shown in Fig. 227. The wired edge is then hammered down to the position shown in the next drawing. This is an excellent way of bringing a wired edge sharply forward. The edge of the stake must of course be quite smooth and true.

Mouldings of almost any section may be produced by means of the drawswage, Fig. 233. This tool consists of a strong rectangular frame with movable dies, which are pressed together by a screw. A groove of the exact section of the required moulding is filed in the adjacent edges of the dies. Then a strip of metal is repeatedly drawn through it, till, the dies having been gradually pressed closer together by the screw, the strip of metal is forced to take the required shape. The frame and dies should be quite rigid, therefore the former should be made from metal not less than ¾ inch wide. It will be seen from the illustration that on the two long sides of the frame the metal projects inwards in a V-shaped ridge, A. This ridge is, however, cut away at the left-hand end of the drawing, so that the dies, into which it fits, may be removed. Each die has a V-shaped groove at either end corresponding to the projecting ridges on the frame. The whole arrangement is very similar to the stock and dies by which screws are cut.

Indeed a very useful drawswage can be made from an old screw stock, especially if it be of large size.

Suppose you wish to make a length of moulding like Fig. 230. Remove the dies by withdrawing the screw and lifting them out of the frame at the gap. On the upper face of C file a groove to the exact section of the moulding required. The shape of the groove may be tested while you are filing it by hammering a piece of lead or other soft piece of metal into it. The lead will take the exact shape of the groove. Modelling wax may be used instead. Alternately file and test the shape of the groove in this way, till you are satisfied with its form. You must now widen it out towards each side of the die that the groove may taper, as the holes in a drawplate are tapered. In a drawplate, however, the tapering is towards one side only, but in the die it is in both directions from the centre. But you must leave the centre of the die untouched. Take great care to prevent any scratch or other roughness being left on the die near the centre, for every mark will be reproduced in the moulding. Nor should any sharp edges or corners be left at the extremities of the groove, for they would cut or tear the moulding instead of quietly pressing it into shape. Take the die B and round off its lower edge on both sides. If B and C are now put together and held to the light the groove should look exactly the right section in the middle, but be wider towards the front and back edges of the dies. They may now be hardened and tempered, but this is not necessary unless a good length of the moulding has to be drawn. Put the dies in the swage. Take a length of wire or strip metal of the nearest to the required section that may be available. It is sometimes possible to save the swage a little work by first flattening the wire or roughly hammering the strip to shape. Anneal it, grease or oil it, and put it between dies B and C. Tighten the screw till they grip the wire. Then on the drawbench pull it through the swage to within half an inch of the end. Screw the dies a little closer, and pull back again in the reverse direction. Repeat the process

again and again; annealing occasionally, greasing frequently, and screwing the dies closer every time. The wire will gradually assume the desired shape.

Mouldings 229 and 230 are solid, and are flat at the back. But frequently a moulding is required, the back of which follows the contour of the front. Less metal is used in this way. Such mouldings are made from strips of sheet metal, instead of wire. The dies are so made that part of C projects into and partly fills the groove in D. If the metal for the moulding is thin, the dies must be made to match each other accurately, and careful attention given to any projecting ridges, which might be likely to cut through the strip.

Small mouldings, up to ⅛ inch, can be drawn by hand, the drawswage being held in the vice. But for larger work some mechanical help must be had. The drawbench, Fig. 233A, is the most generally convenient tool. It is a low bench 5 or 6 feet long. At one end is fixed a roller with strong handles to turn it, at the other a pair of cleats to hold the drawplate or swage. A strap is fastened to the roller and ends in an iron ring, triangular in shape. This slips over the hooked handles of the drawtongs. The extremity of the wire which is to form the moulding is gripped in the drawtongs, and the swage put into position against the cleats. The ring on the strap is now hooked on to the tongs and the strap tightened by pulling the large handles. Very considerable force is required to turn the handles when a wide moulding is being drawn. Geared drawbenches are made, and the strap is sometimes replaced by an endless chain.

When only a short length of moulding is required a groove of the required section may be filed in a piece of steel and the strip or wire hammered into it a little at a time, Fig. 234. The tool should be wide enough to take an inch or more of the moulding at once. No sharp corners should be left at the extremities of the groove. The metal should not be hammered right home at once, but gradually worked

down with the hammer along its whole length, no part being finished till the moulding is nearly complete all along. It may be necessary to anneal it first. If the moulding is not a solid one, it is necessary to lay a strip of lead above the strip of metal which you are to use and hammer them both together into the groove. The lead will press the other metal right into the hollow. A narrow collet hammer of convenient shape may be sometimes used to drive the metal into the groove in the swage, Fig. 235, the lead strip is hammered into the hollow back of the moulding to complete it.

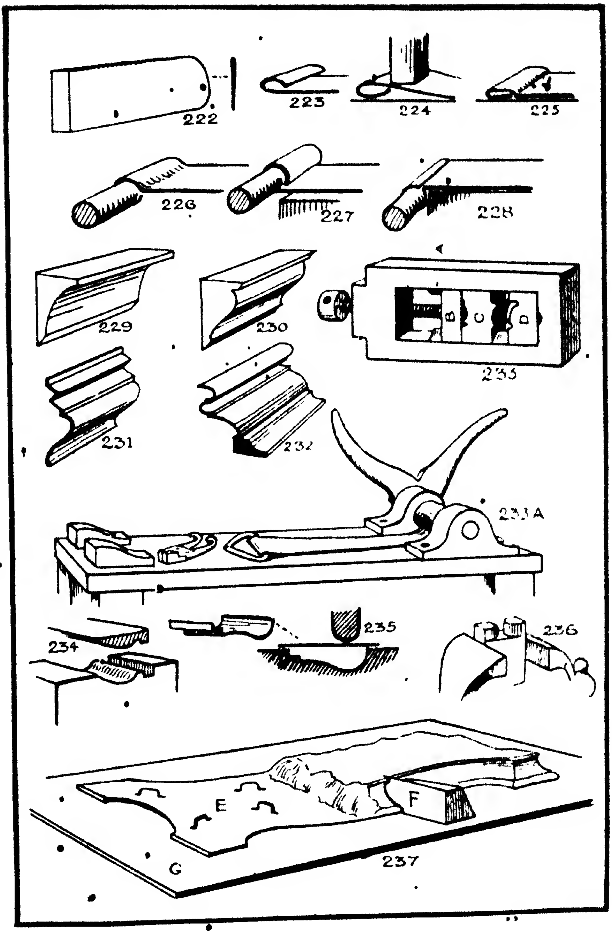
The following is a very convenient method, by means of which any moulding may be produced. Take a length of strip metal of convenient size, bend it round into a ring, and hard solder the ends together. Fix the ring on a chuck in the lathe, and turn it to the shape of the moulding required. Then if necessary cut the ring at the join and straighten out the strip.

You will have, of course, no difficulty in bending into a ring a strip of metal measuring, say, $\frac{3}{8}$ by $\frac{1}{8}$ inch if you bend it in the direction of its smaller measurement. But if you wish to make a flat ring of it, $\frac{1}{8}$ inch in thickness, you may have some difficulty in getting the metal to bend in that direction. You can, however, do the work in the following manner. Take a piece of hard wood measuring, say, 3 by 4 by 1 inch and put it end up in the vice. The vice should grip it in the direction in which it measures 3 inches, and 1 inch of the wood should project above the jaws of the vice. Make two saw cuts $\frac{1}{2}$ inch deep, leaving the exact width of your strip of metal between them. With a chisel remove the wood between the saw cuts, and round off the vertical corners of the notch, Fig. 236. Anneal the strip of metal and put one end of it, flat side up, into the notch. By using the other end of the strip as a lever you can bend the metal to the curve required. Do not cut the ring from the remainder of the strip until you have got it to the exact curve, for the long strip makes a convenient handle

and lever. The ring may try to " buckle " in the process, but a few taps with a mallet on a stake will soon flatten it again. Strip copper up to 1 inch by ¼ inch in thickness may be bent in this way by hand. It goes easier if red hot. The notch in this case must be lined with sheet metal, or, better still, made in a stout piece of metal instead.

Mouldings are often built up from a number of strips, or concentric rings of different sections, soldered one above the other. See Chapter XXVII.

The simplest way of making a complicated moulding, to go round a difficult shape, such as that shown in Fig. 237, is to run it in plaster and then cast it in the metal. First make two brass templates, one to the exact shape of the ground plan, E, the other to that of the moulding, F. Soft solder the first template on to another piece of sheet metal, G, which measures two inches larger all round. Solder also a few loops of wire on top to hold the plaster in place. You don't want it to slide off. Fasten the second template to a small wedge of wood in such a manner that when the latter lies flat on the bench, the template stands up on its edge. Mix a little plaster, as described on page 19, and put some of it on the wire loops and all over the plan. Hold the second template flat on the sheet of metal, G, and rest it against the edge of the metal plan, E. You can now slide the template F along the edge of E; it will scrape off any plaster which has come too far. Add plaster wherever required. Slide F again and again round E, washing the former whenever it gets clogged with plaster. Very soon the plaster on E will get firm, and the template will cut it cleanly. Take great care to hold the wedge of wood to which the template F is fastened, quite flat on G all the while. To fill up small gaps in the plaster mix a teaspoonful at a time, To mix a small amount of plaster like this, take a bare spoonful of the dry plaster and put it, spoon and all, into a basin of water. When the bubbles have ceased to rise from the plaster in the spoon take it out, and beat it up into an even paste. Apply it with a brush, and when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etting run the template by again. Keep template F wet when finishing. When the moulding is free from gaps, it is ready for moulding and casting in its final material.

Mouldings may be produced in sheet metal by modelling it on pitch with repoussé tools. The work may be done from either back or front of the metal. To do this on a large bowl it is usual to work with the side of the bowl bedded in pitch. The bowl is moved round as each section is completed.

Large simple mouldings may be worked with hammer alone on suitably shaped stakes or swages.

CHAPTER XVI

TWISTED WIRES

ORNAMENTAL wires are used in jewellery; in silversmiths' work, for the decoration of mouldings themselves; and alone, as in bangles. In ancient times many varieties were in use, both goldsmiths and armourers displaying considerable ingenuity in inventing and combining different patterns. But in recent years little thought has been given to them, with the result that the varieties in use are now very few indeed. Curiously enough, the Japanese, to whom their decorative qualities might have been expected to appeal, have never shown any interest in them. Mediæval armourers, on the contrary, found in them an unfailing joy, as the numerous wire patterns to be found on sword-grips testify. Mediæval silversmiths also, with their keen attention to every detail of the craft, invented and employed many beautiful examples. That numbered 7, below, for example, gives a most charming play of light and shade. That numbered 30 was used by the ancient Irish metalworkers for some of the splendid gold torques now in the Dublin Museum. Six dozen varieties of wire patterns are shown here, though the number might have been doubled without difficulty. But enough are given to suggest the wide choice open to one in the selection of an ornamental wire pattern for any purpose. The name of the museum in which the pattern was originally found is in some cases added to the description.

1. Square wire twisted to right slowly
2. Square wire twisted to right quickly.
3. Square wire twisted to right quickly, afterwards drawn through round drawplate.

4. Square wire twisted to right quickly, afterwards drawn through square drawplate.
5. Square wire twisted to right intermittently. Grip in hand-vices with leather guards to jaws, or in wood clams.
6. Square wire twisted intermittently to right and left in turn.
7. Square wire twisted alternately to right and left.
8. Flat strip twisted to right.
9. Flat strip twisted alternately to right and left.
10. Four square wires put together and twisted as one. (Bargello, Florence.)
11. Two round wires twisted together quickly.
12. Two round wires twisted together slowly.
13. Two round wires twisted together and afterwards flattened.
14. Two pieces of square wire each twisted to left, afterwards put together and twisted to left.
15. One piece of square wire twisted to right; this and a piece of round wire put together and twisted to right.
16. Two pieces of square wire, one twisted to right and one to left, afterwards put together and twisted to left. The piece which was originally twisted to right is now nearly unwound owing to the left-hand twisting it has undergone.
17. One piece of small twisted wire (two small wires twisted to left) and two large round wires put together and twisted to left.
18. Four square wires each twisted to right, afterwards put together and twisted to right.
19. Two large round wires twisted to left and two strands of twisted wire (two small round wires twisted to left) wound in the grooves.
20. Square wire twisted to right. A small round wire wound on alternate faces.
21. Square wire twisted to left, one strand of small square wire twisted right wound on one face.

22. Square wire twisted to right, a strand of square twisted wire wound on alternate faces.
23. Square wire twisted to right, one round wire and two strands of twisted wire wound on alternate faces.
24. Two strands of square wire twisted to right, put together and twisted to right; one strand of small beaded wire wound between.
25. Four square wires put together and twisted as one. One strand removed and replaced by a strand of beaded wire.
26. Flat strip twisted to right.
27. Flat strip twisted to left, one strand small beaded wire wound on.
28. Flat strip twisted to left, one strand twisted wire wound on. (British Mus.)
29. Flat strip twisted to right, two strands twisted wire wound on.
30. Thin strips soldered together to make a strip whose section is a cross (+). A round wire is temporarily laid in each gap (four). Strip and wires are then twisted as one mass. The four round wires are afterwards removed. (Nat. Mus., Dublin.)
31. Thin strips soldered together to make a strip whose section is a cross (+). A round wire is temporarily laid in each gap (four). The wires in this case are gripped in the hand-vice wherever necessary, and the twist to right or left made as required.
32. Three strands twisted wires twisted together. One strand afterwards removed.
33. One strand twisted wires and one strand round wire twisted together.
34. One strand twisted wires and one strand round wire twisted together (slower twist).
35. Two strands twisted wires twisted together.
36. Two strands twisted wires (three wires each) twisted together.

37. Two strands twisted wires and one of round wire twisted together.
38. Three strands twisted wires twisted together, one afterwards removed and replaced by beaded wire.
39. One plain round wire and two strands twisted wires put together and twisted. One strand of twisted wires, originally the same size as the other, has become partially unwound through being twisted in the contrary direction to that in which it was originally twisted. It was twisted to left at first.
40. Three strands of twisted wires twisted together. One removed and replaced by a fresh strand twisted in the opposite direction.
41. Three strands of twisted wires (two being right-hand twists, the third left-hand, all being of equal size) put together and twisted. A small round wire afterwards wound between the two right-hand twists. Notice how the strand with a left-hand twist has become partially untwisted.
42. Two strands twisted wire (right-hand twist) put together and twisted to left. Opening out.
43. Two strands twisted wire (right-hand twist), left hand twisting continued. More open.
44. Two strands twisted wire (right-hand twist), left-hand twisting carried still further. An entirely new pattern, triangular in section, is the result.
45. Seven equal wires twisted to left loosely.
46. Seven equal wires twisted to left tightly.
47. Seven equal wires, two removed and replaced by strands of twisted wires.
48. Two large round wires twisted together. Two small wires afterwards wound in the hollows.
49. Two large round wires twisted together. Twisted wires in the hollows.
50. Two large round wires twisted together. One strand beaded wire in the hollow.
51. One round wire coiled on a larger wire.

52. One round wire coiled on a larger wire, but pulled apart at intervals.
53. Strand of twisted wires coiled on a large round wire.
54. One plain wire coiled in groove of strand of twisted wire.
55. Square wire twisted and covered with fine wire.
56. Two round wires twisted together and covered with fine wire.
57. One strand like No. 56 and one strand twisted wires (two round wires) twisted together.
58. One strand round wire and one of twisted wires coiled on large wire.
59. One strand square wire and one of twisted wires coiled on large wire.
60. Similar to No. 58, but here the round wire is smaller than the twist.
61. Three strands round wire and one of twisted wires coiled on large wire.
62. One strand right-hand twisted wires, one of left and one round wire coiled on large round wire.
63. Two small wires coiled on large round wire for six turns each. Then the two small wires are twisted together for a sufficient length to make, when wound round the large wire, three coils. Then the two wires are each wound six times round the large one and again twisted together for a short distance as before. It is well to make the commencement and finish of each section of twisted wire come on the same side of the large wire. The slight irregularity at the ends of the twisted portion may then be turned to the side of the work which will not be seen.
64. Same as No. 62, with one slightly larger wire wound on afterwards.
65. Two round wires twisted together. One removed.
66. Square wire twisted, afterwards coiled openly on another which is finally removed.
67. Flat strip coiled openly.

68. Small round wire coiled right on large round wire. Strip coiled left openly over all.
69. Two strands square wire twisted right, put together and twisted right. One afterwards removed.
70. One strand small twisted wires coiled openly on small round wire.
71. Strip and beaded wire coiled on round wire.
72. Strip, one strand twisted wires and two small round wires coiled as above.

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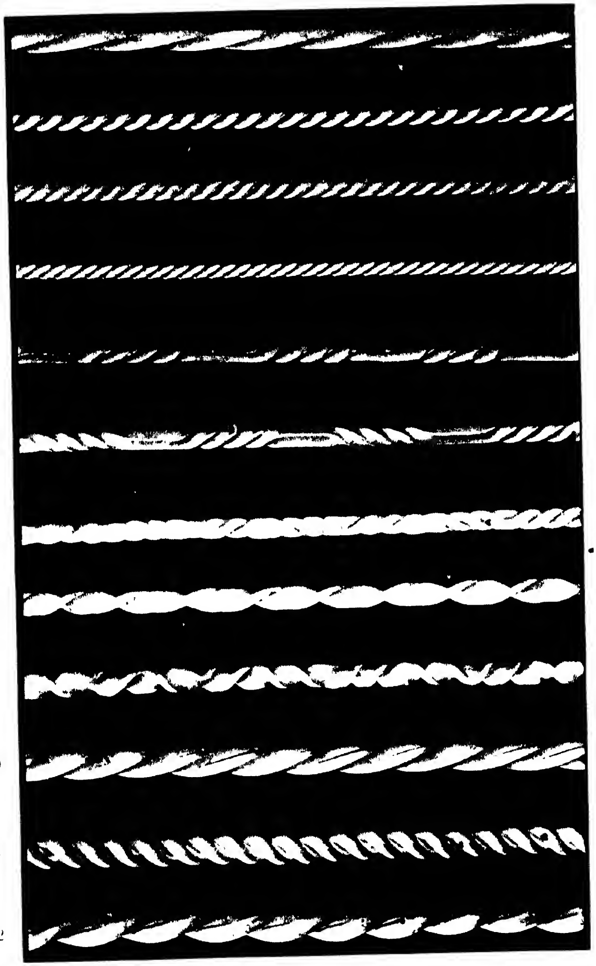

FIG. 238.—A sampler of twisted wire patterns

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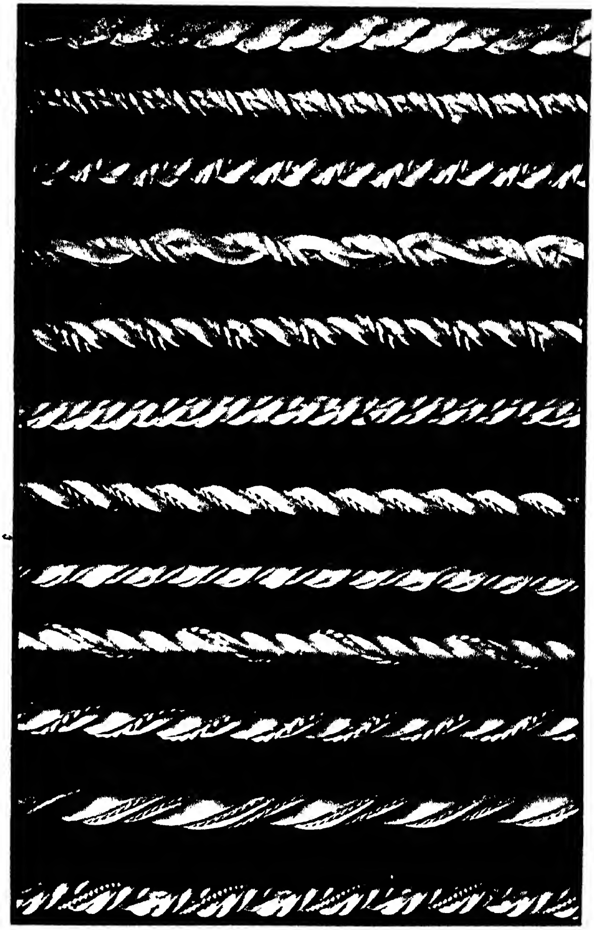


FIG. 239.—A sampler of twisted wire patterns.

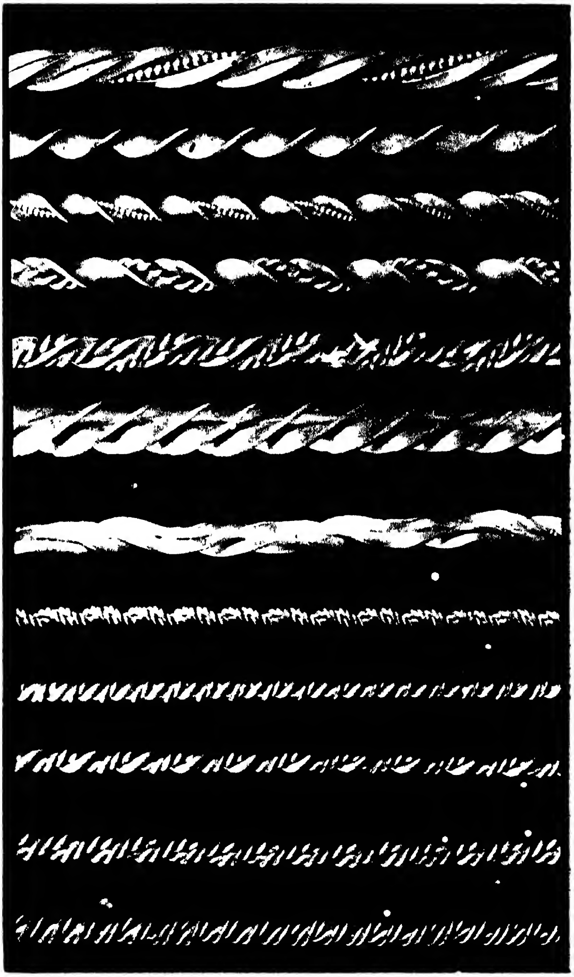


Fig. 240.—A sampler of twisted wire patterns.

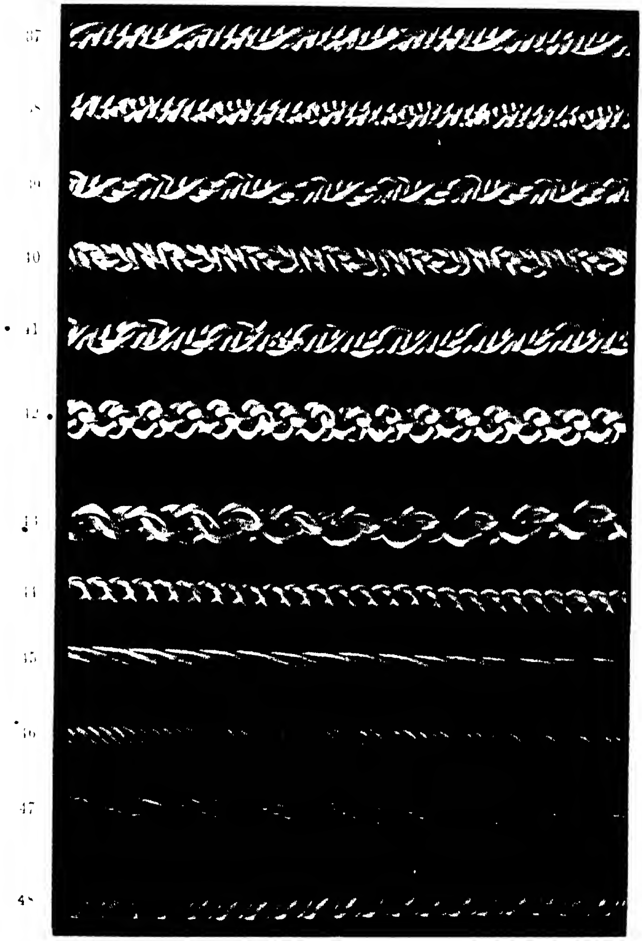


FIG. 241—A sampler of twisted wire patterns.

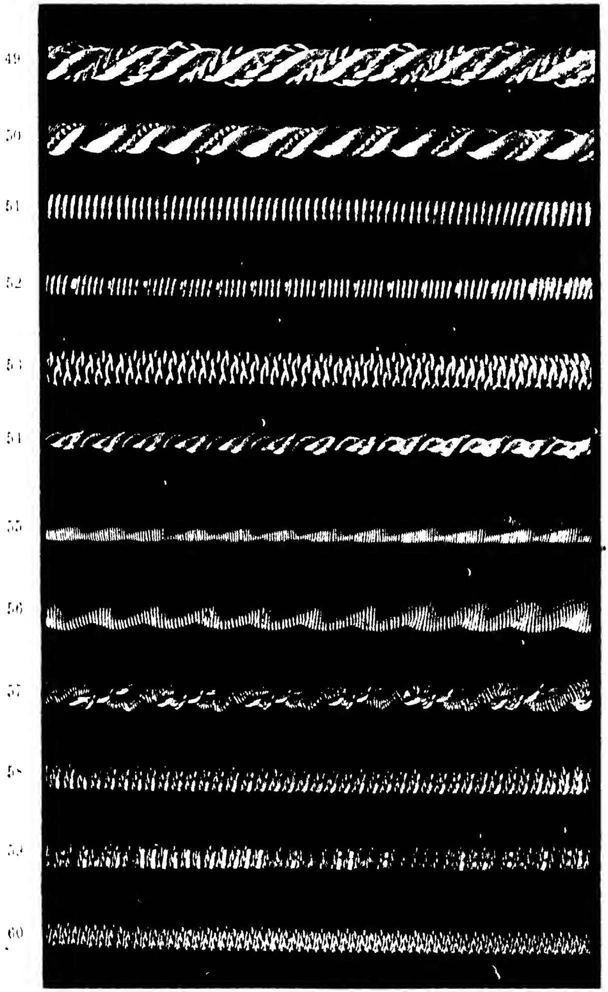


Fig. 212. A sampler of twisted wire patterns

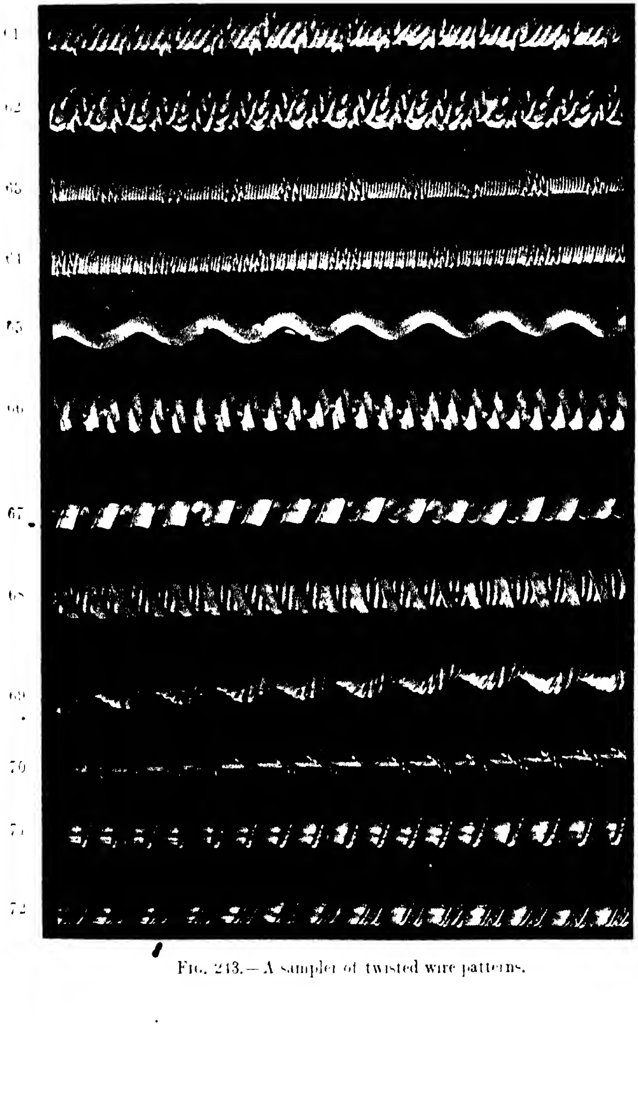


Fig. 213.—A sampler of twisted wire patterns.

CHAPTER XVII

HINGES AND JOINTS

Chenier joints—Joint tool—Soldering—Brooch joints.

THE hinge to the lid of a metal box is composed of a number of short lengths of tube, or "chenier," soldered alternately to the box and the lid. A piece of wire, called the "joint pin," running through them all, keeps box and lid together. The strips of metal, or "bearers," soldered on both box and lid, when the metal of which they are composed is not strong enough to bear the strain of the hinge, have the effect of strengthening the joint. If they are put on the outside of the box they sometimes form also a convenient stop, by means of which the lid is kept from opening too far.

To make chenier. Take a strip of the metal which you are to use, measuring three times the width of the tube you wish to make. Carefully remove any burr or rough edge—if left on it would give you trouble later. Make a point an inch long at one end of the strip by cutting little triangular pieces from the two sides. Lay the strip lengthwise over the groove in a swage block, Fig. 20, or even in a semicircular notch cut across a piece of wood. Tap the strip into the groove with a narrow hammer, Fig. 21, curling the edges up as much as possible—the middle will take care of itself. Then put a drawplate in the vice and draw the strip through a suitable hole. When it has passed through a few holes its edges will meet, and the strip has become a tube. To make sure that the tube is true inside take a piece of copper wire of suitable size, oil it and put it inside the tube. Draw the tube down hard on to it. It is only necessary now to reverse the

drawplate and put the end of the wire through a hole which will only just admit its passage, and the wire may be drawn out of the tube. If the chenier is not quite straight it should be annealed, and a number of little nicks made with a needle file along the side upon which the seam comes;—for this crack shows very little, and it is important later on that there be no doubt as to which side of the tube it comes on. Roll the chenier on a flat stake till it is quite straight. See also Chapter VI. page 46.

You must decide whether you will have the hinge projecting from the back of the box, flush with it or sunk a little way below the surface. In the two latter cases the bearers are soldered inside the box and lid; in the former they are outside. Fit and solder the bearers accordingly. Next make the groove in which the "joints" or "knuckles," *i. e.* the pieces of chenier, are to lie. Take a good deal of care to make this run truly across the box. If it is inclined ever so little the lid will not look straight when the box is open. The groove is to be cut partly in the box and partly in the lid, and it must be just large enough to hold the chenier when the lid is in its place on the box. Fig. 244 shows a joint of five knuckles with bearers, A and B, soldered on outside. Fig. 245 is a flush joint, the bearers being soldered inside in this case. The edges C and D meet when the lid is opened to about a right angle, and keep it from going back too far. In Fig. 246 the joints are sunk below the surface. The bearers are inside in this case also. The wide edges E and F form the stop. They are wide because a clear space of at least 90° from the centre of the pin is always necessary to allow the lid to open as far as a right angle to its position when shut. The joint for the back of a watch is of this sunken type. You will notice the wide bevel near the centre. Fig. 247 shows a hinge which would open beyond the right angle. It would go right back, as it has no stopping edges. The groove may be cut with a file, followed by a round scorper, and finally trued up with a joint file. This is a flat file roughened only

on its edges, and these are rounded. Try the chenier in the groove from time to time. When it fits decide as to how many pieces the joint is to be made in. An odd number is always chosen; and the box always has one more piece than the lid. If the joint is of three pieces only, it is well to make the one for the lid rather longer than either of the others, that it may be as strong as the two opposed to it. If the joint is of five or more pieces, they are made of equal length. Cut each knuckle just a shade longer than it will be required, using a piercing-saw. The ends of each piece must now be filed quite truly at right angles to its length; otherwise there would be uneven gaps between the different pieces, and the lid of the box would not open smoothly.

To true up the ends of the joints you must use the joint tool, Fig. 252. It is a flat piece of hardened steel, perhaps 1 inch square and $\frac{1}{8}$ inch thick, with a small handle. A triangular or kite-shaped hole is pierced through the middle of the blade. The sides of this hole are filed accurately at right angles to the flat surfaces of the tool. The end of the piece of chenier is put through the triangular hole, and clamped in position with a small set screw provided for that purpose. The extremity of the tube is allowed to project just a shade above the surface. This small amount of metal is now removed with a fine file. You continue filing till the file slides across the surface of the joint tool without being able to remove any more metal from the chenier. The extremity of this is now quite truly at right angles to its axis. Level up the extremities of all the joints in the same way. Take off the burr left by the filing. Bevel off also the sharp corner at the ends of the tube near the crack. Do this to the extent of about a third of the distance round the end of the tube. Now lay all the knuckles in the groove prepared for them, and see that box and lid come together fairly all round. Put a little mark opposite the end of each of the joints. Remove the lid, leaving all the chenier in the groove on the box. Fasten

with a clip, or a wire round the box, the alternate pieces which are to be soldered to the box. Remember that the two end pieces always belong to the box, never to the lid. Take particular care that the crack or seam, left up the side of the chenier when you made it, is in each case turned down into the groove, where it will be soldered safely. If you do not attend to this the joint will be liable to open out later on. You can always find the seam if put the file-nicks in, as suggested above. If you lay the joints which belong to the lid between the others you will be able to see that they are all in their right places.

Now very carefully put borax to each of the pieces which belong to the box. Take care that the borax does not spread, or boil up later, to quite the ends of the pieces of chenier. It might catch the lid chenier, and where it goes the solder will go also. Apply the solder, and fire it just enough to tack the knuckles in their places. Remove the knuckles which belong to the lid, and solder all the others quite soundly. You will now see why the corner of the chenier was bevelled off, as above suggested. The solder has crept round the end of the chenier where it lies in the groove and has filled up the little gap which you made when you bevelled off the corner near the crack in the tube. If you had not done so there would not now be room for the lid knuckles to go home. For they filled the whole available space before, leaving no room for the solder to trespass on their ground, as it were. Of course you would not bevel the corner of the chenier all round, for the knuckles would not seem to touch in that case. You bevel the tube only at the part which fits in the groove. Some workers stop the solder from running too far by painting the work there with rouge, loam, tripoli or whiting. Always put just the correct amount of solder to fill the joint: not too much nor too little. When the soldering is completed, boil out the box in pickle. See that none of the knuckles have shifted. Then fix and solder the lid knuckles in the same way; and boil that out. Then carefully put box and lid together and

run a wire through all the joints. See that everything goes truly. You may like to smooth out the inside of the joint with a broach. Smooth up the chenier both inside and outside the box. Finally take a brass wire which fits, wax it, and push it home. If the box is a silver one it is usual to plug the extremities of the joint with pieces of silver wire, the brass wire being cut correspondingly short. In a good joint the lid should gently close itself when tilted. It should not stick or drop. To make sure that all the knuckles are in a direct line with each other, it is a good plan to run an oiled steel wire through them all, and to leave it in while the soldering is proceeding. You will find this steel wire a great help when wiring the knuckles in their places.

For a lightly made box the bearer is often made from a section of the tube called the port-chenier or the counter-chenier. You proceed as follows. Draw down a piece of tube till it will fit tightly round the chenier from which the knuckles are to be cut. Force the chenier inside and anneal both together. They will then fit each other exactly. See that they are quite straight. Roll them on a piece of plate glass to ensure this. Then withdraw the chenier. Split the other tube in half, lengthwise, with the piercing-saw and file the edges of each piece true. Cut the joints from the other chenier, true them all in the joint tool and bevel their corners near the crack. Lay them in place within the two halves of the split tube, taking care that the cracks in the knuckles in each case are turned against the split tube, where they will be safely soldered. You may now tie all together with binding wire and solder each alternate knuckle to its own piece of the split tube. In applying the borax take great care to prevent its spreading from one knuckle to another, for it would take the solder along also when the work was heated. Fire the work till each knuckle is just tacked in place by the solder, then separate the two halves of the joint and thoroughly solder all the knuckles. Boil out before you try to put the two

halves together again. When the joint is complete you may solder each half in place on the box.

A brooch joint can be made in a number of different ways. We will take the chenier joint first. As a rule, several of these are made together. Take a piece of metal, size 6 on the metal gauge, and make from it a tube which you draw down till it is about $\frac{1}{16}$ inch in diameter. With a fine saw make a number of cuts beginning on the side where the crack is and extending two-thirds the way through the tube. The cuts to be $\frac{3}{32}$ inch apart. You have now a number of tiny lengths of tube all attached to one another at one side. With the saw cut away as much as possible of the second, fifth, eighth, eleventh, fourteenth and so on, but do not weaken the strip so much that it breaks apart. Your tube now consists of a short length of tube, a gap, two short lengths, another gap, two short lengths, a third gap and so on, all connected on one side, Fig. 248. Next take a strip of metal size 6, as long as the tube, and $\frac{1}{8}$ inch wide. Tie the tube on to this with its cut side against the strip. Solder the two together, taking care that every one of the pieces of tube remaining is soldered safely. After boiling out, cut away with the saw all the pieces which join the lengths of tube together, Fig. 249. You would have had a good deal of filing to do if you had soldered the whole length of tube to the strip, instead of making the saw cuts and removing every third length, or rather as much of it as was possible. Cut another strip of metal $\frac{1}{8}$ inch wide size 6, and tie it against the tube at right angles to the other strip. It is to form the bearer or spring, against which the pin of the brooch presses. After soldering it in position, Fig. 250, you can cut your long strip into lengths—two pieces of tube with a gap between. This short length represents the part of the hinge which is fastened to the brooch itself. The pin part has yet to be made. In some joints which can be bought ready made, the tube and the bearer are made from the same piece of metal. They are therefore very strong.

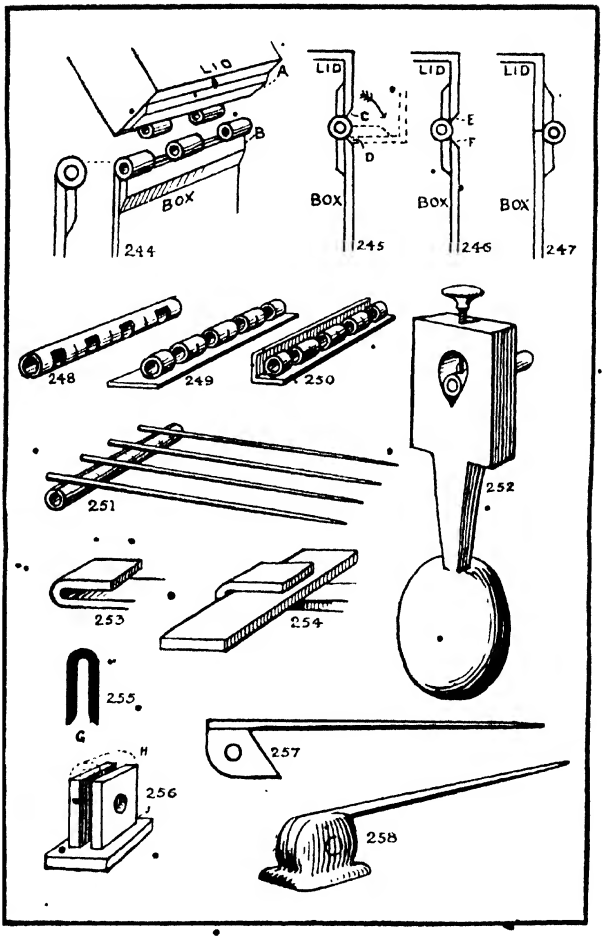
To make the pin, take a short length of the same tube which you used for the other part of the joint. Lay it flat on the charcoal with the crack or seam side uppermost. Across it, at intervals of $\frac{1}{8}$ inch, lay lengths of the wire which you are to use for the pins. Allow $\frac{1}{4}$ inch of the wire to project over the tube, Fig. 251. Solder each of the wires to the tube, making sure that the crack or seam down the tube is safely joined in the process. With a fine saw, cut through the tube between each pin. The soldering will have made the pins soft, so seize both ends of each pin in turn with pliers and twist it until it is quite hard. Then cut off the $\frac{1}{4}$ inch projecting wire. Very little filing will be required to allow the tube to drop into the gap in the other part of the hinge. The pin or pivot of the hinge can now be slipped in, and its end expanded with a few taps from a hammer. Sometimes the bearer is soldered to the pin instead of to the other part of the hinge. And sometimes a flat strengthening piece is soldered to the pin to protect it from the pressure of the bearer.

A hinge which will take less room than the joint above described is known as the ball joint. To make it, take a strip of metals, size 10, a full $\frac{1}{8}$ inch wide. Grip $\frac{1}{8}$ inch of the end of it in the pliers and fold it back on to the strip as much as possible, Fig. 253. Slip another piece of metal of the same thickness between the two parts, and tap flat, Fig. 254. Cut off the U-shaped piece from the strip and bevel off with a file a little of the inner top edges (marked G) of the U, Fig. 255. The U-shaped piece is to be soldered upside down on to a little metal plate, or even directly on to the back of the brooch. The rounded part of the U is now cut off, Fig. 256, and you have two parallel plates of metal standing up. Now take the pin and solder a tongue of metal $\frac{1}{8}$ inch deep, and $\frac{3}{16}$ inch long lengthwise underneath one end of it. Harden the pin by twisting or hammering it. File the tongue to the shape shown in Fig. 257. Then push it between the two vertical sides of the U, and drill through all three pieces together. If you had not bevelled

off the inner edges of the U first, the solder employed in fixing it in position would have rounded off the inside corner against the backplate, so the tongue would not have gone home as it should. The projecting corner of the tongue presses against the blackplate and forms the spring of the hinge. With the file round over the top and sides of what remains of the U, then rivet the pin in. In another kind of ball joint the U-plate is made just as above described, but the curved part of the U is not cut away. It is allowed to remain, and acts as the bearer against which the pin springs. The U-plate is soldered so that the corner H, Fig. 256, is turned round to the position marked J. The tongue or blade of the pin, of course, has no need of the projecting corner shown in Fig. 257, as the pin springs against the rounded part of the U-plate.

A very safe joint can be made from rings of square wire soldered into position. The join in the rings should in each case be against the backplate. The bearer is added as above described.

The catch of a brooch is generally made from a ring of half-round wire soldered to a backplate. The opening in the ring being in this case at the side, and not against the back plate. In some cases no backplate is used, the catch being made from flattened wire curled up as required and soldered to the back of the brooch.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CHAPTER XVIII

METAL INLAYING

Piercing the recesses—Punching them—Chiselling them—Engraving—Etching—Etching grounds—Transferring design—Needling—Mordants—Fusing the inlay—Depositing it—Hammering it in—A Japanese method.

THE practice of inlaying metal plates or lines into another plate of different colour is one of considerable antiquity. Beautiful specimens of the craft have come down to us from the Mycenæan age of ancient Greece, *circa* 1400-1000 B.C. And to-day the Japanese craftsmen show us how valuable these little touches of colour can be made. In this respect and in the production of patina European craftsmen have much to learn from the East, and particularly from Japan. The all-over, brilliant polish of the average production of the silversmith is not the last word which can be said on the subject. Except in the case of table-ware, the obvious cleanliness and brightness of which would seem to be desirable, the use of coloured inlays or patina could be largely adopted.

One of the simplest methods of inlaying is that on which the pattern is drawn on a piece of sheet metal and cut out with the piercing-saw. Pieces of the metal which is to form the inlay are sawn to fit the openings, and afterwards soldered in to fill them. The whole work is then polished. If the two pieces of metal which are to form background and pattern are clamped together, the ornament may be sawn out at the same time and by the same cut which pierces out the opening to receive it. But you must allow for the width of the saw cut, for this would leave a little space all round the pattern to be filled up with solder. The best plan is to have the metal which is to form the inlay

ather thicker and softer than the background, so that vhen it is put in place it may be hammered a little and tretched to entirely fill the opening.

Parquetry inlays can be made in the same manner as hose in wood. A number of narrow strips of the different netals employed are laid edge to edge and solder d together, Fig. 259. The compound strip is then sawn, at an angle o its length (sometimes 90°, but often less) into a number of strips, each the width of the required fillet. The ends of he strips are joined and the edges filed true. You have now a long fillet made up of alternate bands of the different netals employed, Fig. 260.

If two or more wires composed of different metals are wisted together, annealed, drawn a few times through a quare drawplate and then flattened by passing them hrough the rolls, they may be used as a fillet for inlaying, and will look not very different from one made in the manner lescribed above.

Inlays which do not go right through the metal into which hey are fastened, must have the lines and spaces to receive hem prepared in one of the following ways. The recesses nay be (1) left at the time when the work is cast, stamped or electrotyped, or (2) cut, chiselled or punched out, or (3) etched out by acids or other mordants. Patterns and ines to receive inlays may be produced by means of chasing and repoussé tools. For instance, with the tracer described on page 125, a narrow groove may be produced in the surface of a piece of metal. The line is then gone over again with a narrow, parallel-sided chisel with flat bottom. The groove made in this way will be square at the bottom, and it will have a little bank or ridge, formed from the metal driven outwards by the tools, on either side. These ridges are tapped down and form overhanging sides to the groove. The wire which is to form the inlay is now thoroughly annealed, laid in the groove and hammered home. The surface of the work is scraped and polished.

The metal to be inlaid, if thick, can be supported on a

solid stone or metal base, or it may be fixed on pitch while the groove is being prepared. Thin metal may be supported in the same manner; but the pitch should be allowed to get quite cold before the work is commenced; for if the pitch is soft, the background near the line traced will be depressed by the hammering, and will require to be tapped back afterwards. The forms of leaves, rosettes and other ornamental patterns may be stamped into the metal with suitably shaped punches, or spaces of any form "punched down" with ordinary repoussé tools. Letters and numbers may be worked with the ordinary letter or number punches. A metal straight-edge clamped down on to the work, or a suitably shaped paper pattern, gummed down, will serve as a guide in setting out the letters—the side of the punch resting against the rule or paper.

But to cut out the recesses with hammer and chisel, or by means of graver and scorpers is the more usual method. A heavy piece of work such as a brass inscription or memorial tablet, is supported on a solid base of stone or iron. To this a ledge projecting half an inch above the surface of the slab makes a good stop, it keeps the work from sliding about under the influence of the hammering. The chisels used are of various kinds. Some are graver-shaped, Figs. 261, 262, for outlining the pattern; and others flat-faced, and perhaps $\frac{3}{16}$ inch wide, for chipping away the material, Fig. 264. They are made about 6 inches long. The letters or design may be traced on to the metal with carbon paper, and then inked in—drawings made thus show up clearly. The chisel for outlining is triangular or lozenge-shaped at the point, Fig. 261. To sharpen it, lay one of the lower sides flat on the stone. Then lift the hand a little and rub until you have produced a facet on the tool. Do the same on the other side of the tool. The side view of the point is shown in Fig. 262. The ridge separating the two facets just made must be in line with the ridge which separates the two under-sides of the tool. The little angle or corner where the two facets meet the under-sides of the tool is

very valuable in practice, for the tool slides along on it as the point cuts its way. Next rub down the back of the tool, B, keeping to the original angle. The sharpness of the point may be tested by touching it with the thumb-nail. It should stick at once without slipping. If a wide line is required, the graver may be made to cut it by sharpening the tool on the under-side or belly, grinding away the lowest angle of the diamond for perhaps a quarter of an inch along the ridge. A tool so sharpened is called a lozenge scolloper, Fig. 263. But scollopers or chisels with parallel sides are made also; they are sharpened on front and back, and are made in several different widths.

For the smaller work done by engravers, the hammer is not required. The tools used have a small round handle, held in the palm against the ball of the little finger. They are known in this case as the graver or "burin," and scorpers. The latter are made in various shapes—flat, round, knife-edged, etc., see page 68. Engravers hold their work in various ways, much depending on its shape. (1) On a sandbag. This is a round pad of sheepskin, crammed very tightly with sand or whiting, or a mixture of whiting and plaster of Paris. This is better than sand, for there would be no danger of scratching the work should any of the contents escape. The work is held by the left hand on top of the bag, and turned about as required. (2) In a chuck or clam, Fig. 265. (3) On a pitch bowl (see Chapter XXVIII, page 252). (4) On a cement stick. (5) On a triblet or ring stick, Fig. 270.

The design is drawn on the metal as described on page 243. The work being then held firmly, the engraver either outlines the pattern with the graver and afterwards removes the ground with scorpers, or cuts the ground away at once without troubling to outline it. The point of the graver should be pushed along just below the surface of the metal, firmly and without jerks. Or, the work may be turned or pushed against the point of the graver, while it is held more or less still. A deep line is cut by going over the same ground a

second time. The graver may be made to cut a line of varying width. To do this it is only necessary to rotate the tool on its axis a little. The graver being diamond-shaped in section, this rotation brings part of one of the sides rather than only a corner into contact with the metal, and a wider cut is the result. If a flat scorper is rotated quickly from side to side and at the same time pushed forward, it will make a curious "wriggled" or zigzag cut, Fig. 266. This is a quick way of removing the ground, and it leaves the surface of the metal very rough. This is an advantage in some processes of inlaying—when a "well-keyed" ground is required.

The third method by which recesses for inlaying may be prepared, is that of etching. Gold, silver, copper, brass, bronze, iron or steel, may be treated by this process. The work is first covered with a specially prepared wax or varnish "ground," and the design drawn on it with a steel point or "needle." The ground is in this way scratched through wherever the lines which form the design or pattern come, and the metal exposed. Some acid is then poured over it. The acid attacks the metal wherever it is not protected by the varnish and eats or bites a furrow wherever the needle has gone. The depth to which the lines are "bitten" depends a good deal on the strength of the acid solution, and on the time the work remains in the "bath," for the longer a line is exposed to the action of the acid the deeper and wider is it bitten. It will be seen then that a design may be etched in lines of varying thickness, for it is only necessary to "stop out," *i. e.* cover up with varnish, any lines which are sufficiently bitten, and then to put the plate into the bath again till the remaining lines are finished. Or, the deep lines may be drawn and etched first and the faint ones drawn in afterwards and bitten only for a minute or two. The length of time required to etch the pattern may be but a few minutes, or it may be an hour or two.

Rhind's is perhaps the best-known etching ground. It

may be purchased from all dealers in etching materials. Another good etching ground (Bosse's), very widely used, is made as follows:—

White wax	10	parts
Gum mastic	6	,,
Asphaltum	3	,,

Melt the wax first in an oven. Stir in the other two. The ingredients must be very thoroughly mixed. The stirring must be continued long after any streakiness in the mixture has disappeared. This ground is quite black, though a thin layer of it is semi-transparent. If the asphaltum is left out the ground is quite transparent, but not quite so strong. Another ground is made of:—

Yellow beeswax	2	parts
Asphaltum	2	,,
Burgundy pitch	1	,,

Mix as above described.

When cool roll the ground into balls about 1½ inch in diameter. For use, a ball of ground is tied up in a double thickness of thin silk, blue-bag fashion. Beeswax, paraffin-wax, or shellac, dissolved in alcohol or chloroform may also be used for a ground, or for stopping out any part of the work which has been bitten deeply enough. Remember that lines get wider the longer they remain in the acid.

To ground a plate or other piece of work. Clean it thoroughly. Then heat it until it is rather too warm to hold. It may be held in a hand-vice over a gas- or spirit-flame, or laid on a piece of sheet iron and the heat applied below. When quite uncomfortably warm to the touch lay the plate on a table and dab or rub the ground all over its face. To spread the ground evenly it is usual to either roll a rubber squeegee in every direction over the surface of the plate, or to use a dabber, Fig. 267. This is made of horsehair

silk or kid. The edges of the silk or kid are brought over a disc of cardboard and bound together with string in the centre of the disc, above, to form a handle. The dabber is patted over the work until the ground is spread quite evenly. It may be necessary to reheat the plate before this can be effected. The ground having been spread evenly over the plate, its surface is now blackened by moving it about a few inches above a bundle of lighted tapers. These give off a good deal of smoke and soon darken the ground. When cool its surface should have a quite smooth, blackened, half-polished appearance, and lines scratched by the needle should show up brightly in contrast. Work which by reason of its shape cannot be grounded in this manner, may be dipped into a vessel containing some of the etching ground, melted; or, the ground may be dissolved in oil of lavender or chloroform and painted over the work. It is well to remember that the whole of the work except the scratched-in design must be protected from the action of the acid, so the under-side and edges must be protected as well as the face. The old copper-plate etchers, however, used to make a little wall of wax round the edge of the plate which was to be bitten, thus turning the plate itself, with its wax rim, into a kind of trough, into which the acid could be poured. The back of the plate did not then require protecting.

Designs may be transferred to the etching ground in the following way: Take a thin sheet of paper and go all over it with a soft black-lead pencil. Use the side of the point of the pencil, for it will make a broader mark. Cover the paper with close lines in several directions, till it has a grey, shiny surface all over. Lay this side of the paper on the etching ground, and put the paper on which your drawing is, above. Then go over all the lines of the drawing with a fine point, pressing firmly, but not hard enough to penetrate the paper. The black lead from the lower sheet of paper will be transferred all along the lines to the wax ground, and show up in contrast with its blackened

surface. If you have an etching press, it is only necessary to put your lead-pencil drawing, or a tracing of it, face downwards on the ground and pass work and drawing together through the press. The drawing will be reversed in the process, and care must therefore be taken with lettering.

The needle used to scratch through the ground is just a pointed piece of steel. An ordinary sewing-needle set in a handle does very well. For broad spaces in the design, a chisel-shaped tool may be used instead. Or, a number of lines drawn so closely together that the acid may work its way from one to the other. A low wooden bridge laid over, but not touching the plate, forms a convenient rest for the hand. When the design has been gone over with the needle the plate is ready for biting. But first see that every part of the metal, except the scratched-in design, is protected from the action of the acid. Paraffin wax or Brunswick black may be used to cover any exposed parts.

The acids or mordants used for the different metals are given below. They should be got ready at least an hour before they are wanted;—the ingredients taking some time to mix properly,—but then, in glass-stoppered bottles they will keep for months.

Mordant for gold—

Hydrochloric acid	8 parts
Nitric acid	4 ,,
Perchloride of iron	1 ,,
Water	40 to 50 parts

For silver—

Nitric acid	1 part
Water	3 or 4 parts

For copper, brass, etc.—

Nitric acid	1 part
Water	1 ,,

Sir Frank Short, R.A., the well-known etcher, gives the following mordants for copper plates—

Nitric acid	1 part
Water	1 "

Or—

Nitric acid	1 part
Water	2 parts

Or—

Dutch mordant—

Chlorate of Potash	2 parts
Hydrochloric acid	10 "
Water	88 "

Or perchloride of iron. This bath consists of a 40% Baumé solution of perchloride of iron in water.

The Dutch mordant is much slower in its action than the others, and the line bitten by it does not spread so much in width.

Mordant for iron or steel—

Hydrochloric acid	2 parts
Water	1 "

In mixing these solutions remember that the acids should be poured into the water, not the water into the acids.

Lay the work face upwards in a porcelain dish and pour the mordant over it to a depth of a quarter of an inch. Bubbles of gas will immediately form all along the scratched lines. Rock the dish gently from side to side or wipe the bubbles away with a feather. If they are allowed to remain the line will not be etched evenly, for the gas in them keeps the acid away from the work. As stated above, the time required to etch the pattern may be a few minutes or an hour or two. Watch the plate and try the depth of the biting from time to time with a needle. To stop out any part which is sufficiently bitten remove the plate

from the acid, rinse it in water and paint some of one of the grounds, described above, over the parts which are bitten deeply enough. When the biting is completed, remove the plate, rinse it in water, warm it and then thoroughly clean with turpentine. Then wash with hot water and soap. Dry in hot sawdust. Or, after the turpentine, the work, if not composed of iron or steel, may be boiled out in sulphuric acid pickle as described on page 24. Etched patterns are often trimmed up with the graver.

The recesses having been prepared in one of the ways described above, the inlaying must now be considered. There are three entirely different methods by which the pattern may be filled in. By the first the inlay is fused into the hollows. By the second it is deposited in them by the electroplating or the amalgamation process. And by the third it is hammered or burnished in. The first two are by far the most satisfactory, for the intimate union between inlay and inlaid, like that between a solder and the work soldered, ensures a perfect and permanent hold for the inlay. Any metal or alloy which can be used as a solder for another metal can be used as an inlay for it. Thus brass or silver solder may be used to fill recesses in copper; brass or gold in iron, etc. Flux must be used just as in soldering. To fill large spaces pieces of sheet metal or wire may be soldered in. When all the lines and spaces have been filled up and fired, all superfluous inlay and solder can be cleared away with a fine file, and the work polished smooth. Iron or steel weapons and armour "damascened" with gold in this way are well known. Soft solder may be used in a similar manner for the decoration, say, of copper.

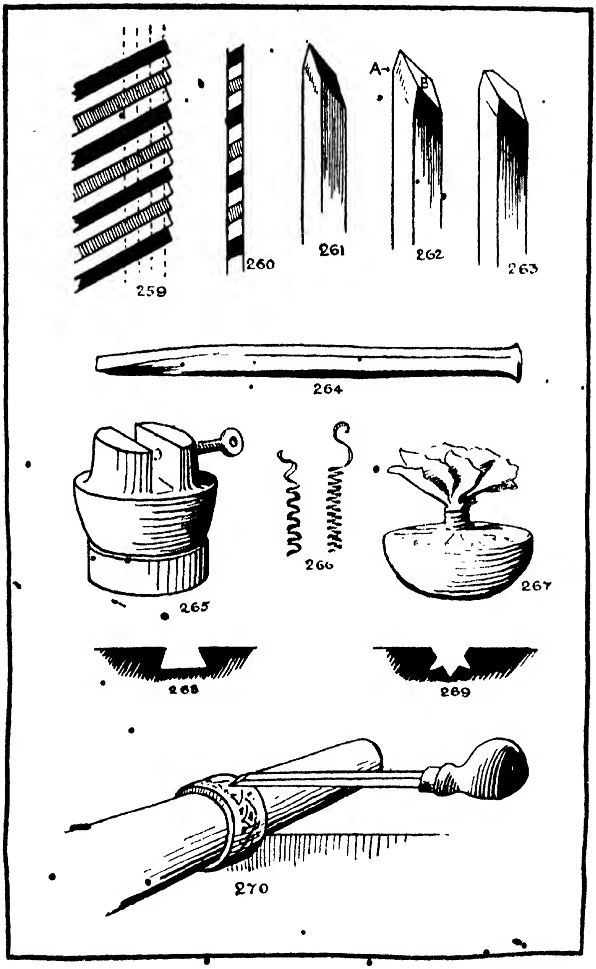
By the electroplating process any metal or alloy which can be electro-deposited may be used for inlaying, those parts of the work on which the deposit is not required being protected by a coat of wax or varnish.

Damascening. Silver may be inlaid with gold in the following manner. Fine gold is filed to very fine powder and kneaded with an equal weight of mercury in the palm

of the hand until an evenly mixed amalgam is obtained. The engraved silverwork is rubbed with "grey powder" (mercury with chalk). This slightly amalgamates the surface. The gold amalgam is piled into and over the recesses, and the work left for a day or two. The amalgam should be pressed down in the hollows occasionally. The work is next placed on a warm hob so that the mercury may evaporate slowly. Its fumes are very injurious, so avoid them. This gentle heating may go on for many hours, but the work must be heated at last to low redness to drive off every particle of mercury. Then burnish the gold well, scrape down and polish the work.

When wire is to be used for the inlay the groove into which it is to be hammered must be wider below than at the surface of the work, Fig. 268. This undercut form may be produced by widening out the deep part of the groove first cut, or little additional grooves may be cut with a knife-edge scorper at each side of the bottom, Fig. 269. These afford sufficient key to hold the wire when it has been hammered in. An etched line, though rather uneven at the bottom, is not wide enough there to hold the wire safely. It must be widened out like the other. The gold or silver wire for inlay should be, if possible, of pure metal. It is softer than metal containing alloy, and it has a better colour. Anneal the wire, and lay one end of it in the groove. Take a hammer which is nearly flat on the face and tap the wire into the hollow. See that no part of the groove remains unfilled. Then file or scrape the whole surface level. In another kind of damascening the surface of the metal is roughened, and gold foil or layers of pure gold-leaf burnished on, or hammered on with punches.

Japanese workers have another method. They take the piece of iron or steel which is to be inlaid, anneal it, and cement it firmly on to the resin block, which corresponds with our pitch block. Then with a light hammer and a fine chisel the surface of the metal is hatched with a number of fine, parallel cuts, quite close together. The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work is then turned round and a second series of cuts made at right angles to the first. A third and a fourth set in the direction of the diagonals complete this part of the work. The iron has now an even, dull, roughened surface, like a mezzotint plate. The design is formed of gold wire bent into shape on the plate, and tapped into it with a hammer; the microscopic spikes which form the surface of the iron penetrating the wire and holding it firmly. The work is painted over at intervals with lacquer—very little of which, however, is allowed to remain actually on the surface. It enters the pores of the iron and makes it proof against rust. The pattern then tells up in gold against the dull brown of the lacquered iron.

CHAPTER XIX

NIELLO

Theophilus—Cellini—Bolas—Spon.

NIELLO is a composition of silver, lead and sulphur, or of other ingredients, used from early times for filling-in engraved patterns. The dark grey or black colour of the niello contrasts well with gold or silver. Cloisonné wire patterns are sometimes filled with niello, as on the Cross of Cong, in the National Museum, Dublin.

Perhaps the earliest description of the manufacture of niello is that given by the eleventh-century monk, Theophilus. His treatises on gold- and silver-smiths' work, translated by Robert Hendrie, may be met with occasionally. He gives a delightful account of the manner in which he and other goldsmiths of his time did their work. In the chapters on niello, quoted below, he is describing the decoration of a two-handled chalice (Book III, chapters xxviii, xxix, xxxii, and xli).

"Take pure silver, and divide it into two equal weights, adding to it a third part of pure copper. When you have placed these three into a cast metal cup, weigh as much lead as half of the copper which you have mixed with the silver weighs, and taking yellow sulphur break it very small, and put the lead and part of this sulphur upon a small copper vessel, and place the rest of the sulphur in another cast metal cup. And when you have liquefied the silver with the copper, stir it evenly with charcoal, and instantly pour into it the lead and the sulphur from the small copper cup, and again mix it well with the charcoal, and with quickness pour it into the other molten cup upon the sulphur which you had put into it, and then putting

down the small vase with which you have poured out, take that into which you have cast it and place it in the fire until [the contents] liquefy, and again stirring it together pour into the iron crucible. Before this cools beat it a little, and warm it a little, and again beat it, and do this until it is quite thinned. For the nature of the niello is such that if it is struck while cold it is immediately broken and flies to pieces, nor should it be made so warm as to glow, because it instantly liquefies and flows into ashes. The niello being made thin, put it into a deep and thick cup, and pouring water upon it, break it up with a round hammer until it becomes very small, and taking it out, dry it, and put that which is fine into a goose quill and close it up, but that which is coarser place again in the vessel and bruise it, and being again dried, put it in another quill.

"When you have filled many quills take the gum which is called parahas [borax] and grind a small piece of it with water in the same vase, so that the water is made scarcely turbid from it, and first moisten the place which you wish to blacken with this water, and taking the quill rub off the ground niello with a light instrument upon it carefully, until you have covered the whole, and do this over the whole. Then gather excessively hot coals [charcoal], and placing the vase in them carefully cover them, so that no coal be placed, nor can fall, over the niello. And when it is liquefied hold the vase with the pincers and turn it from every side on which you see it flow, and in thus turning it round take care that the niello does not fall to the ground. But should it not be completely perfect at the first heating, again moisten it, and superpose [niello] as before, and take great care that no further work is required.

"When you have mixed and melted the niello, take a portion of it and beat it square long and slender. Then take the handle [of the chalice] with the pincers and heat it in the fire until it glows, and with another forceps, long and thin, hold the niello and rub it over all the places which you wish to make black until all the drawings [engraved

spaces] are full, and carrying it away from the fire carefully make it smooth with a flat file until the silver appear, so that you can scarcely observe the traits and so scrape it with the cutting-iron, carefully cut away the inequalities, and you will gild what remains. . . .

". . . Scrape all the parts carefully which are blackened with the neillo, with the cutting instrument. Afterwards you have a black and soft stone, which can easily be cut and almost scraped with the nail, and with it you rub the niello, wetted with saliva, carefully and smoothly everywhere, until all the drawings are plainly seen, and it is quite smooth. You also have a piece of wood from the lime tree, of the length and thickness of the smallest finger, dry and smoothly cut; upon which you place this wet powder, which comes from the stone and saliva in rubbing, and with this wood and the same powder you rub the niello a long time and lightly, and always add saliva, that it may be wet, until it is made brilliant everywhere. Then take wax from the hollow of your ear, and when you have wiped the niello clean with a fine linen cloth, you anoint it everywhere, and with goat or hart's skin you will lightly rub it until it is made quite bright."

Benvenuto Cellini, in his treatise on goldsmiths' work also described the making of niello. He used—

Silver	1 part.
Copper	2 parts.
Lead	3 „
Powdered sulphur.	

The silver and copper were first melted together and the lead added to them. The crucible was then removed from the fire and the liquid metal stirred well with a piece of charcoal held in the tongs. The scum caused by the oxidisation of some of the lead was skimmed off, and the stirring proceeding till the three metals were thoroughly blended. A narrow necked earthenware flask, about as big as the fist

was half-filled with powdered sulphur. Into this the molten metal was poured. The mouth was closed with damp clay; and the flask, held in a piece of stout canvas, thoroughly shaken. When it had cooled, the flask was broken open, and the metal, which had now combined with the sulphur, was found in the form of little black grains. These were melted in a crucible with borax, cast into an ingot, and again broken up. This operation was repeated several times before the niello was considered to be properly mixed.

Mr. Bolas, in his little book *Etching on Metals*, gives "an easily fusible niello" suitable for all kinds of work, large or small—

Native sulphide of antimony, finely ground	2 parts
Native sulphide of lead (galena), finely ground	1 part
Sulphur in small fragments or powder	8 parts.

These ingredients should fill less than half of a fireclay crucible. Heat gently and stir all the while with the stem of a pipe. If the mixture is overheated or not properly stirred it will become thick and stiff. When properly fused it may be poured out on a slab of stone. The niello is then coarsely powdered. A less fusible niello of finer black colour, and specially suitable for small articles in silver or gold, is described by Mr. Bolas. It is composed of—

Silver	2 parts
Copper	4 ,,
Antimony	1 part
Lead	1 ,,
Sulphur.	

Melt the silver and copper together, add the autimony and lead, and cast into an ingot. Reduce it to powder by filing it with a smooth file. Mix the filings with twice their weight of powdered sulphur. Drop this mixture, a teaspoonful at a time, into a crucible maintained at a low red heat.

Allow the crucible to cool, break it, and, with pestle and mortar, finely powder the black sulphide. Mix the powder with twice its weight of sulphur and melt it again. Then break up the niello—into small grains rather than to fine powder.

The work should be thoroughly cleaned before the niello is applied. Mr. Bolas recommends that the final cleaning shall be with a stiff brush and some gritty powder, such as bathbrick dust,—care being taken to brush it all out. Etched silver work should be rubbed with a fine wire scratch brush to remove any silver oxides which may have been left in the recesses. Fill all the hollows with the small grains of niello, and pile a little on top to make up for the smaller space which the fused material will occupy. Drop over it a little powdered borax,—very little. Heat the work until the niello melts, and at this time, go over it with a hot iron spatula (Mr. Bolas says, a pipe-stem made hot) to assist in completely filling the recesses. Be careful not to allow the work to get red hot, or even to remain hot for longer than you can help, or the lead, which is one of the components of the niello, will rapidly corrode the silver or gold of which the work is composed. If the work is not flat, the niello may be dropped into the recesses of the heated metal as it is turned about, and worked into place with the hot spatula. Now remove any superfluous niello with a file. But before you have quite got down to the surface of your work, heat it again till it is rather too hot for the hand to bear, and with a steel burnisher and a little oil burnish well the surface of the niello. The object of this burnishing is to stop up any little bubble holes which may have come in the process, and which would otherwise spoil the surface of the work. Then scrape the surface of the work true and polish in the ordinary way.

Spon gives—

First crucible—	Flowers of sulphur	27 oz.
	Sal-ammoniac	$2\frac{3}{4}$,,

Second crucible, which after fusion is poured into the first—

Silver	½ oz.
Copper	1½ ,,
Lead	2¾ ,,

Add a little sal-ammoniac to the mixture. Reduce to powder, mix with a small proportion of a solution of sal-ammoniac for use. Spread the niello on the work. Heat in a muffle till the composition solders to the metal. Polish level, as above.

CHAPTER XX

JAPANESE ALLOYS

Mizu-nagashi—Mokume—Shaku-do—Shibu-ichi.

SOMETHING akin to inlaying is the Japanese work in banded alloys. The late Sir William Chandler Roberts-Austen was the first in this country to describe the work in valuable papers read before the British Association and the Society of Arts more than twenty years ago. But it is still little known or practised.

The Japanese workman takes thin plates of various metals or alloys—gold, silver, copper, and various alloys of these metals—and solders them together. In the thickish plate thus produced conical holes are bored, or grooves cut, as shown in Fig. 271. These cuts penetrate the various layers and expose them in rings or bands. The plate is then hammered flat in front. Or the thick plate is hammered or rolled out thin, and then beaten up irregularly from behind with repoussé tools. The bumps in front are then filed flat, and parts of the various layers of which the plate is composed become visible in front. The different strata exposed form an irregular marbled pattern. The work is known as mizu-nagashi. Another variety is called "mokume" (wood grain). It is made from alternate layers of light and dark coloured metal,—the effect of wood grain being exactly imitated.

Work of this kind can be used to give interest and colour to an otherwise plain surface. It is not difficult to produce. The various sheets of metal to be used should be rolled down to size 1 on the metal gauge, or even thinner. They should then be boiled out in pickle, again in a solution of washing soda and water, and lastly in clean water. They should then

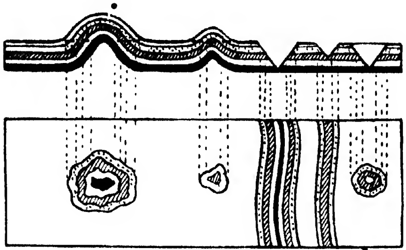
be held by the edges only,—for to touch their flat surfaces with the hand might leave a trace of grease, which would interfere with the soldering. Now paint all their surfaces with borax and tie the plates together with wire. Lay paillons of silver solder all along two adjacent sides and heat till the solder has run through all the joints. The plate may now be folded on itself to make it double the thickness, and the two halves soldered together. It will of course have twice as many layers as it had at first. This process of doubling the plate and soldering it may be repeated as often as desired. The resulting thick plate may be rolled out afterwards. It will consist of a large number of thin layers of the various metals used, all united by solder. The back of the plate can now be beaten to drive up bumps in front. These may form regular patterns if desired, or be quite irregularly shaped. Holes may then be drilled into the plate exposing the various layers. The bumps are then filed flat with a similar result. Should you file right through the plate at any of these places it will not matter much, for pieces of metal may be soldered into the holes from the back. The plate is then hammered flat. It may require annealing. Its surface will be composed of irregularly shaped bars, stripes, rings and spots of the various metals employed, giving a delightful mottled appearance.

An interesting variety of this work can be produced as follows. Take thin wires of various metals and twist them to form a cord. Coil this upon itself into a spiral. Solder the coils together. Beat or file the surface flat. The pattern produced is a curious spiral of various coloured metals, Fig. 272.

The Japanese use a number of alloys for this and other work. The two principal ones are known as—

1. Shaku-do. This is composed of copper with 1½ to 4 per cent. of gold, and traces of silver, lead, etc. The addition of this small proportion of gold, enables the copper to take a beautiful purple colour when pickled in the solution given on page 263.

2. The second alloy is known as Shibu-ichi. It is composed of 2 parts copper, 1 part silver, and traces of gold and iron; or of about equal parts of copper and silver and a trace of gold. It takes a fine silver-grey colour. The



271

272.

use of these alloys, each of which is made in several different shades gives to the Japanese craftsman a much wider range of colour than is generally open to his European brother. For to the Japanese artist the intrinsic value of the material employed counts but little in comparison with its artistic or colour value. To him, fortunately, hall-marking is unknown.

CHAPTER XXI

ENAMELLING

Tools and materials—List of enamels.

ENAMELLING is here dealt with technically. For a true appreciation of the artistic and historical side of this supreme craft the reader is referred to a little book on *Enamels* by Mrs. Nelson Dawson, herself one of its most gifted exponents.

Let us look first at the material itself. Enamel is a kind of rather soft glass—composed of flint or sand, red lead and soda or potash. These ingredients are melted together and produce an almost clear glass with a slightly bluish or greenish tinge. This almost colourless material is known as flux or frit. It is made in different degrees of hardness,—those kinds which contain more lead and potash are more brilliant, but softer. Soft enamels require less heat to fire them, and are, therefore, convenient to use, but they do not wear so well. So for any work which has to stand friction hard enamels are essential. Clear flux or frit is the base from which coloured enamels are made,—the colouring matter being metallic oxides. The addition of two or three per cent. of one of these oxides is generally sufficient to produce a strong enough colour. The enamel, after being very thoroughly stirred, is poured out into cakes four or five inches in diameter. It is afterwards broken up, ground in a mortar to a fine powder, thoroughly washed, and spread evenly over the surface of a piece of metal. It is then placed in a furnace and fused. The firing enables the enamel to hold firmly on to the metal. Such in its simplest terms is an enamel—a vitreous substance fused on to a metallic background.

The tools required for enamelling are not many, the furnace

being the principal one, Fig. 273. Furnaces are made in many patterns and are heated by gas, electricity, coke or oil Gas-heated furnaces are the most generally used. They consist of a muffle surrounded by a casing of specially prepared fireclay. Fletcher gives 1 part fireclay to 3 or 4 parts sawdust, moistened, worked into form and burnt, as the material from which furnace casings are made. Heat is supplied to the furnace by a row of Bunsen burners underneath. To avoid the heat radiated by the chimney it is well to fix a shield before it. Some enamellers use also a hanging glass screen as an additional protection. A small enamel may be fired in an ordinary clay crucible heated by the blowpipe, or even in a piece of iron folded in half; but the enamel should not be exposed to the direct blast of the flame, or it may be discoloured. This method, however, is rather dangerous for firing small silver articles—they melt so easily. A pair of tongs about two feet long, with slender handles and jaws, is necessary, Fig. 276. One or two palette knives, with blade about a foot long, are useful for lifting the work on and off the metal plate on which it rests for firing.

A set of boxes, or of wide-mouthed bottles, to hold the enamels should be numbered to correspond with the printed list of colours as supplied by the makers. It is a good plan also to have a set of samplers of the different colours, prepared in the following manner. Take a number of plaques of thin copper, measuring, say, 1½ inch by 1 inch. Dome them up as described on page 197. Coat one third of the surface of each with white enamel, one third with clear flux and the remainder with the enamel you wish to test. Fire them. Then lay a strip of silver foil, prepared as described on page 202, across the three stripes as indicated in Fig. 274. Cover the foil, the white, and the flux with a coating of the coloured enamel; and fire the plaque again. You will now have a sampler which shows how the colour will look when fired directly on to copper; and when fired on flux, on white, and on foil. The colour will look quite different on each. It will be most brilliant on the foil, next on the white or the

flux, and deepest on the copper. It is only necessary now to paint the number on the sampler, and a figure to indicate if it is a soft, hard, or very hard colour. You decide this by arranging small pieces of all the enamels you wish to test on a plaque, and noticing the order in which they fuse when in the furnace. You should take care in doing this that all the colours are ground equally fine, and that the heat of the furnace reaches them all to the same extent.

In addition to the above, the following will be required,—one or two porcelain pestles and mortars, Fig. 277; a small agate pestle and mortar, and one or two small spatulas, Fig. 275; a set of little china pans to hold the enamels when ground, Fig. 278; a slab of plate glass and a glass mullor, Fig. 279, for grinding colours for painting with; a corundum stick, and polishing materials; tools for engraving and repoussé work; rouge or whiting to protect any solder on the work from the heat of the furnace; some gum tragacanth dissolved in water. Cunynghame, in his book on *Enamelling*, says that the best way to dissolve the gum is to powder it well and wet it with alcohol before putting it in water. A porcelain dish and some fluoric, nitric, and sulphuric acids complete the list.

The metals usually employed for enamelling on are copper, silver and gold. Enamel will not hold on commercial brass, though it will on some bronzes. Iron can be enamelled, as we know to our sorrow, for enamelled iron advertisements are fairly plentiful. Platinum will not hold enamel well, though it may be used in small pieces for foil. It is almost impossible to induce enamel to stay upon electrotypes; and of course, the softer metals—aluminium, tin, zinc, etc., will not stand the heat necessary for the fusing of the enamel. But in gold, silver and copper we have three splendid metals for our purpose.

Silver or gold foil (over which a thin coating of colour is fired) is often employed to produce a brighter spot of colour than could otherwise be obtained; for translucent colours look brighter on gold or silver than on copper.

Enamel is applied to the work in a number of different ways. It will be well, therefore, for closer examination, to divide enamels into the three groups suggested by the late Sir A. W. Franks.

1. Inlaid enamels, where the outlines are formed by metal divisions. This group includes champlevé and cloisonné enamels, and those without backgrounds, known as plique à jour.

2. Transparent enamels, where the outlines and other markings are produced by variations of depth in the sculptured ground over which the vitreous substance is floated. These are known as bassetaille.

3. Painted enamels, where the outlines are made by a difference in tint of the enamel itself,—the enamel completely covering the metal base beneath.

There are a few enamels extant, such as those on the Ardagh Chalice, which do not come completely within any one of the above groups. They will be discussed afterwards.

A list of useful enamels is given below. The numbers correspond with those of Soyer, of Paris, the well-known makers of enamel colours. To commence with, those marked with a dagger should be purchased. One or two ounces of each would be sufficient, except for No. 3. Silver flux goes well on copper.

Transparent Colours.

† 2. Flux for gold.
† 3. „ „ silver.
14. Brown.
15. Yellow.
† 17. „ No. 3.
19. Red, cerise.
21. Violet, No. 52.
53. „ Star.
† 23. Blue.
† 27. „ Ship.
† 29. Lilac, No. 1.
† 32. Maroon, S.M.
† 36. Black, No. 62.
40. Red, dark.
† 41. „ clear.
† 44. Rose, flesh.
† 45. Turquoise, Star.
† 48. Green, No. 3.
† 52. „ Star.

Opaque Colours.

† 54. White, Ship.
61A. ,, No. 5 (tinted full cream).
69. Pale blue.
70. Grey, coffee colour.
† 72. Ivory.
75. Yellow, light.
82. Turquoise, No. 1.
84. Green, half dark.
88. Grey, pearl.
90. Blue, opaque.

Iridium black, prepared for painting.

CHAPTER XXII

ENAMELLING (*continued*)

Champlevé enamels—Cutting or engraving—Grinding enamel—Washing enamel—Filling the recesses—Firing enamels—Polishing and finishing.

INLAID ENAMELS. (*a*) *Champlevé*.

IN this work recesses, to be afterwards filled with enamel, are carved, chiselled or etched out of a thick metal plate; or they may be prepared by casting, Fig. 280. The design should be so arranged that each colour has a line of metal right round it. It is better, therefore, not to make the design too complicated. The lines, also, should form a definite part of the design, no attempt being made to hide them. They are afterwards gilt. The metal should be fairly stout, size 14 on the metal gauge, or even thicker for large work. Gold should be not less than 18 carat, and fine silver should be used rather than standard. The engraving of the plate must be taken in hand first. It is the most important part of the work. The design is drawn on the metal as described on page 243. In Chapter XVIII, on Inlaying, are given directions as to the manner in which the hollows may be excavated. But it is not enough simply to remove the metal. For when translucent enamel is used, as it generally is on gold or silver, any unevenness in the floor of the recess shows up very distinctly through the enamel. In the old champlevé work (usually done on copper), the enamels were, as a rule, opaque, so any irregularity did not matter. But in much modern work on the precious metals, where translucent enamel is used, its shape is of considerable importance; for, when it will not interfere with the design, it is carved into regular patterns, generally with a round scorper. This work is, however, more correctly

described as bassetaille than champlevé enamelling. The depth of the engraving may be anywhere between $\frac{1}{50}$ and $\frac{1}{20}$ inch. A greater depth than this is not desirable, for the enamel is less likely to flake off if it is in a thin layer. It is a good plan to float water colour paint into the recesses to enable you to judge the effect of the engraving. The engraved floor of the recess makes a good "key" for the enamel to hold to. In large recesses this keying is very important. Even if opaque enamel is to be used it is well to roughen the surface by digging the point of the graver into it every here and there, or by "wriggling" it with a flat scorper, see Fig. 266. Translucent enamels do not go so well on copper, in champlevé work, as on gold or silver, for the light does not seem easily to get down to the bottom of the recesses to throw up the colour of the enamels above. For inlaid enamels in copper, therefore, opaque colours seem to be best.

The engraving completed, the metal must be thoroughly cleaned. If there is any pitch or cement on it, it may be removed with paraffin. If the metal is slightly warmed the work is easier. It should then be washed in hot soda and water, the face being finally cleaned with methylated spirit. On no account should the work be boiled out in pickle, for this would dull all the clean cutting, so that you would have to go over it again. Nor should you touch the engraved surface with the hands, they might leave a trace of grease. If the work must be left for a while it should be put into a vessel of distilled water and covered up. In this and all other processes of enamelling absolute cleanliness is essential.

The enamels have next to be ground. If a large amount of this material has to be prepared at once it is well to lay the lumps of enamel on an iron plate and put them into the furnace till they are quite hot, but not fused. Then drop them into a bowl of clean water. The lumps of enamel will crack all over and break up very easily in the mortar. A porcelain mortar 4 or 5 inches in diameter may be used,

though an agate one is better, but much more expensive. A small agate pestle and mortar may, however, be bought for five shillings, and it is extremely useful for fine work. Put some of the enamel in the mortar and cover it with water. Set the mortar on a pad of cloth or on a sandbag. Hold the pestle vertically with its lower extremity resting on the enamel, and with a mallet strike the top of the handle to crush the lumps. Keep the pestle away from the sides of the mortar. The water will keep the fragments of enamel from flying about. When all the larger pieces are broken, hold the pestle in the right hand and the mortar with the left, still on the pad, and grind the enamel to powder.

Now the coarser the enamel is ground the more brilliant it will be when fired. But if it is ground very coarsely indeed, it will not cover the metal very well, nor go into narrow spaces, and it will retain air bubbles when melted. So, as a rule, the coarsest you can leave it at is about the size of silver sand. The water will by this time have become milky. This discolouration is due principally to extremely fine particles of enamel, and to some extent to the grinding away of the pestle and mortar. But it must be entirely got rid of. So pour it away, add fresh water, stirring the enamel about. Directly it settles pour off the water. Do this again and again until quite clear water comes away. With translucent enamels this thorough washing is essential if their brilliance is to be preserved, but it is not so necessary for opaque enamels. The cleanly washed enamel should be kept under water in a covered vessel. Very coarsely ground enamel will keep for years, in water, in stoppered bottles, but finely ground enamel rapidly deteriorates if exposed to the air.

With a spatula carefully fill each of the spaces with enamel. The Japanese use a pointed piece of cane for this purpose. Take great care to work the enamel well into the corners and along the sides of the recesses. Keep it off the top of the dividing lines. Press the enamel down firmly,

leaving its surface rather above that of the surrounding metal. To assist in keeping the enamel in place it is well to add to it a few drops of a weak solution of gum tragacanth or of quince-pips. Saliva will answer the same purpose. When all the spaces are filled, the work is ready for the furnace. Put rouge, loam or whiting over any solder that may be on the work—to protect it from the heat of the furnace. But take care that none of these materials get into the enamel. Cover the work to keep any dust from falling on it.

To fire an enamel. Have ready a piece of sheet iron or nickel, a little larger than the enamel itself, upon which it may rest while in the furnace. It must be of such a shape as to support the work evenly. Not more than about an inch of the edge of an enamel should go unsupported, or it may sag when heated. A number of holes may be bored in this furnace-plate to allow the heat to get at the back of the enamel quite freely. To keep the enamel from sticking to the iron plate the latter is sometimes coated with rouge, whiting or plaster of Paris. A little alum, gum, or borax mixed with these materials will help to keep them from crumbling when heated. With continued heating thick scales form on iron, and sometimes come off at inconvenient times. They make black specks in the enamel if they get on to it, so see that the plate is in good order each time before you put the enamel on to it. It may be cleaned with a hammer. Nickel does not scale. Copper, of course, will not do at all. Lay the enamel on the plate, and rest them on the top of the stove to dry. Take great care that this is done thoroughly, for if any moisture remains when you put the work in the furnace, it may boil up and blow your enamel about. When quite dry grip the plate firmly with the tongs, and taking great care not to shake or jar it in any way—for the enamel is in a very fragile condition now—put it in the furnace. Hold it there for a second or two, without putting it down. Then withdraw it. If any steam rises from it, it is not dry enough for firing. If any enamel falls off, withdraw the work instantly and put it in

a cool place. Moisten it with water and repair the damage, adding a drop or two of the gum solution. Then dry the work again. When quite dry put it down in the furnace without shaking it in any way, and close the door. Do not put the tongs down or attend to any other matter whatever while the work is in the furnace,—it requires all the attention you can give it. The time required to fuse the enamel varies from a few seconds to several minutes. Open the top of the furnace door and watch it carefully. When it has once begun to melt it may be removed for a second or two to see how it is getting on, and immediately replaced. But for certain special effects, such as the obtaining of a clear coating of flux of bright golden colour on copper, it is essential that the firing be completed as soon as possible. The hotter the furnace the better for this purpose. If you move the tongs or a long palette knife about over the enamel while it is in the furnace you will be able to tell when the enamel is fused, for the reflection of the tool will be visible on the shining surface of the work. When this is so, withdraw the work immediately. Put it in a warm place, free from draughts, to cool down.

For the second and all subsequent firings the plate upon which the enamel rests should be made red hot before the enamel is put on to it, and it should be replaced in the furnace with the enamel upon it, before it has time to get cool. The enamel may be conveniently lifted from the place where it has dried on to the red-hot plate, by means of a large palette knife. But this is a rather delicate proceeding if, as described later on, there is unfired enamel on the under side of the work. At the second and later firings the enamel cracks as the heat reaches it, and fuses together again when it gets red hot. The plate is heated to enable the enamel to reach this high temperature with as little delay as possible. When the work has cooled down examine it carefully. If any of the metal in the recesses is still uncovered, scrape it bright with a knife, removing at the same time any discoloration along the edge of the enamel

near the uncovered spot. Wash with a little fluoric acid to avoid any milkiness in the enamel where you have scraped it,—see below. Cover all the bare places with fresh enamel and fill up any hollows which may be left elsewhere. Careful drying is not quite so important now as at first, but do not put the work in the furnace while wet. Again cover up any solder. Fire the work, putting it on to the hot plate as described above. Repeat these processes till all the hollows in the work are completely filled with enamel. If it is convenient to do so, after the last firing, turn out the gas and replace the work in the furnace, when it has cooled a little. Take care that the heat in the furnace does not rise high enough to melt the enamel again. Leave the enamel in the furnace till it has cooled right down. The enamel will then be nicely annealed, and any subsequent cracking will be unlikely. Of course, it is not absolutely necessary to do this, for an enamel may be taken straight from the furnace and cooled almost immediately under a stream of water. But not every enamel will stand such treatment, and one hardly likes to risk a valuable one.

The surface of the enamel after the last firing will be rather uneven. To smooth it, hold it when cold under a tap of running water, and grind the surface down to the level of the surrounding metal with a corundum stick. This will give you a smooth unpolished surface. To regain the shining surface of the enamel you may either replace the work in the furnace and fire it again, or polish it. The latter is the better, though slower way. But if you decide to refire it for any reason—a piece chipped out in the grinding to be filled up, for instance—you must first wash a little fluoric acid over the face of the work. For though the running water has carried away nearly all the material ground off by the corundum, yet some has worked its way into the surface. This would, if the work were fired again, show up as a milky film. But the fluoric acid, which has the power of dissolving glass, will remove it.

The acid must be kept in a lead or gutta-percha bottle, for it attacks nearly everything else. But the better way to regain the bright surface of the enamel is to polish it. Go over it with a fine corundum and water; then with pumice stone and water; afterwards with water-of-ayr stone and water; then with crocus powder on a strip of leather, and finally with rouge and wash-leather. You will in this way, obtain a most brilliant surface, which will bring out the precious quality of the enamel. With some of the Chinese and other Eastern opaque enamels, however, this part of the work is not carried quite so far,—the work being left with an egg-shell polish, which is very beautiful.

The polishing of the enamel will have smoothed the metal also. If there are any large plain spaces of metal left, a light pattern may be engraved on them now. It will help to bind the enamelled and the metal parts of the work together. If the work is of copper the metal parts should also be gilt. Great care should be taken during this process to prevent the work from being subjected to any sudden changes of temperature, which might cause the enamel to crack. To ensure safety in this respect, gild it yourself by the mercury process. It is not safe to put the work into a hot gilding solution.

CHAPTER XXIII

ENAMELLING (*continued*)

Cloisonné enamels—Making, fitting and soldering cloisons—Plique à jour Temporary backgrounds—Bassetaille enamels.

Inlaid Enamels. (*b*) *Cloisonné*.

In this work the recesses for the different coloured enamels are formed by narrow strips of metal or wire which are fastened on to the background, Fig. 281. It differs, therefore, from champlevé work, in which the recesses are carved out from a thick piece of metal, leaving the divisions standing up. Champlevé work was generally executed in copper or bronze; cloisonné work probably arose when the old craftsman began to enamel on gold, less of the precious metal being required by this process. The wire used by Byzantine workers was about $\frac{1}{100}$ inch thick and $\frac{1}{50}$ to $\frac{1}{32}$ inch high.

To make a cloisonné enamel, transfer the design to a thin sheet of metal in the ordinary way, then scratch it in with a steel point. Draw down some gold wire of oblong section till it is little more than $\frac{1}{32}$ inch wide, and size 1 or 2 on the metal gauge in thickness. Anneal it. Then with fine pliers bend it to the shape required, trying it from time to time against the design. Cut it off where necessary with a sharp chisel against a smooth piece of brass, not with shears. With the chisel you can cut the end at exactly the angle you wish. If there are many cloisons to be got ready it is well to gum them on to a piece of glass or card to keep them safely. When all are prepared, clean the back plate, and fasten down each cloison in its place with borax with which a little gum tragacanth has been mixed. This will keep the cloison in place when the borax boils up;

or the cloisons may be fixed with gum alone at first, the borax and solder being afterwards applied. The solder used should be as hard as possible, composed, say, of 4 parts silver to 1 of copper. For silverwork it should be free from zinc, for this ingredient burns out in the firing and shows as a dark stain through the enamel. It may even cause the enamel to chip off above it. It is well, therefore, to allow as little of the solder as possible to flow on to the background. The Japanese do not now solder the cloisons down at all. They fix them with rice paste or gum and proceed at once to fill in the enamel. When this is fired it holds the cloisons firmly. However, it is a good plan to solder down some at least of the cloisons, the outside ones and the principal divisions, say. They are otherwise inclined to float about with the enamel. Any solder which would be exposed to the direct heat of the furnace should be covered up with rouge or whiting before each firing, otherwise it might run or burn. In either case considerable damage might be done. When all the soldering is completed the work must be boiled out in pickle. Background and cloisons should then be scraped bright, any loose cloisons put in place, and the enamel filled in. The work then proceeds just as described for champlevé.

Inlaid Enamels. (c) *Plique à jour.*

Enamels of this type have no background. They are like miniature stained-glass windows, the lead lines in the windows being represented by the metal cloisons in the enamel. The filigree wire pattern which is to hold the enamel is built up in the ordinary way, see page 60, or it may be in some cases formed from a thick sheet of metal pierced with holes of suitable shapes. In either case those parts of the work to which the enamel is to hold are scraped bright and clean. The work is then, with U-shaped iron-wire clamps, fastened down temporarily on to a sheet of some material to which enamel will not stick. Now there are

several such materials—platinum, aluminium-bronze, or mica—these leave the underside of the enamel clean and smooth after firing; and tripoli, fireclay or pumice—which do not. Take, say, a sheet of aluminium-bronze, size 10, a little larger than the work, burnish one side and lay the wire network on to it. Tie or clamp the wires down, so that they will not move while you are filling in the enamel, Fig. 282. Proceed just as in champlevé work. Remember always to cover up any solder with rouge or whiting before each firing. When the firing is completed remove the clamps. Give the bronze a few light taps if necessary, and it will come away from the enamel at once. The underside of the enamel should then be very carefully polished. If you use mica for a temporary background it is well to lay it on a piece of iron, and to clamp the wires round that. If the enamel is to take a curved shape the platinum or aluminium-bronze background must first be hammered to that shape, and the wire work made to fit. A very beautiful piece of work in the museum at South Kensington is illustrated in Fig. 382. The enamel here is in very high relief,—cabochon shape. Such a work could be executed by piling up the enamel high above the cloisons by repeated application of fresh enamel to that already fired. Or by preparing a platinum or aluminium-bronze plate in which depressions are made to correspond with the bosses of enamel. The gold cloisonné pattern would be clamped upside down on to this and the recesses filled with enamel in the ordinary way. It probably would be well to use largish lumps of enamel, instead of finely ground powder. Other works by the same artist, Count Suau de la Croix, have enamel in high relief on both sides of the wirework. This would indicate, I think, that the recessed background was used, and that the enamel was piled up high above the cloisons also. M. Fernand Thesmar of Paris has also executed some wonderful works in plique à jour enamel. One of these, a little bowl, is in the South Kensington Museum.

There are other ways by which plique à jour enamels

may be executed. The temporary background for the enamelling of a bowl is formed from the sheet copper, and gold wire is used for the cloisons. When the enamelling is completed, the copper bowl is dissolved by the action of nitric acid, the gold and enamel being unaffected. There is yet another manner in which work of this kind may be fired. The metal framework is supported in a vertical position on the plate which goes into the furnace, Fig. 283. Each opening is then carefully filled with enamel, with which is mixed a little gum tragacanth. The work is carefully dried and put into a very hot furnace. It is removed before the enamel has time to run down. The gaps are then filled up and the firing repeated. Work of this kind is very fragile, and looks as though a soap-bubble had been blown on to the wires.

Transparent Enamels. *Bassetaille.*

In this work the design is carved in low relief at a little distance, $\frac{1}{50}$ to $\frac{1}{20}$ inch, below the surface of the work—very much as described above for champlevé. But in this case the different colours are not separated by metal lines as by that process. They are laid down side by side in close contact. In both, the enamel is filled in to the original level of the metal, and polished smooth,—the strength of the colour varying with the depth of the relief. The carving of the relief must, of course, be done with very great care, for the work will be clearly seen through the enamel. Water colour paint floated over the relief will help you to judge the depth of the cutting. Bassetaille enamelling is executed as a rule on gold or silver. Perhaps the finest example extant is the St. Agnes Cup in the British Museum, Fig. 380.

In applying the colours it is well to mix a little gum tragacanth with each as you put it in its place, and to allow each patch of colour to dry a little before you lay the next alongside it. If you do this very carefully you can keep

each colour from spreading beyond its proper limits. Hard enamels should be used, for they are less likely to spread than soft enamels, and they wear better.

In some cases it is more convenient to prepare the metal base for the enamel by repoussé work than by engraving or carving. The metal employed for this work is naturally much thinner, perhaps size 4 or 5. Metal as thin as this can only be enamelled safely, if it is covered with a layer of enamel on the underside as well as on the face. The reason for this is given in the next chapter.

Cast work can be enamelled, though the enamel has a great tendency to flake off,—days or perhaps months after the work is completed: but a careful preparation of the ground will considerably lessen this danger. The edges of the recesses should be slightly undercut; the whole ground should be pecked over regularly with the graver—to give the enamel a good key; and the work, when done, should be very carefully annealed, by being allowed to remain in the furnace while it cools down, as described above.

CHAPTER XXIV

ENAMELLING (*continued*)

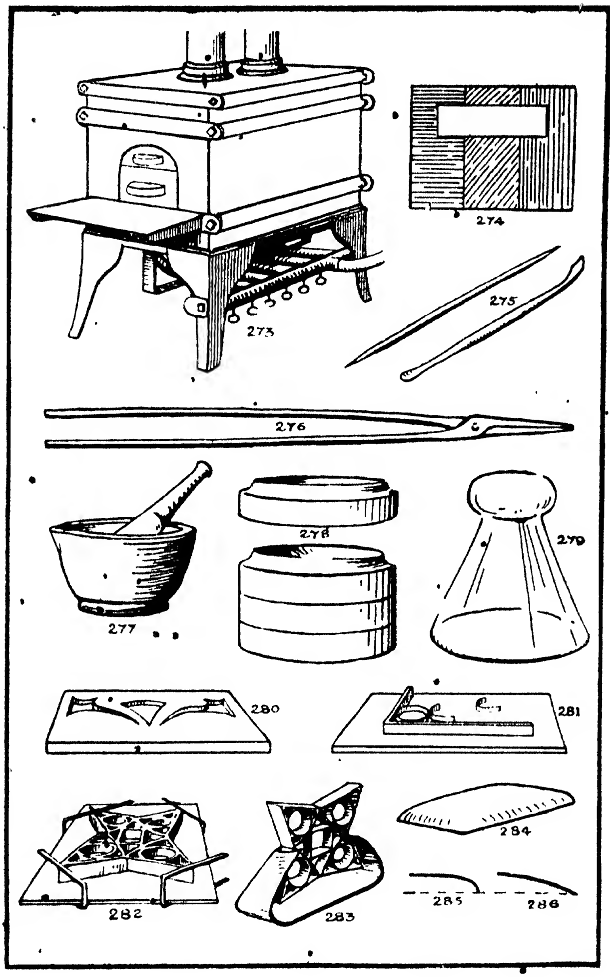
Painted enamels—Preparation of plaque—Backing—Grinding colours in mortar—Applying the enamel—Drying—Firing—Foil—Grinding colours on slab—Painting—Gold—Alterations—Grisaille, etc.

PAINTED ENAMELS.

CHAMPLEVÉ and cloisonné enamels had been made for many centuries before it was discovered that the metal outlines between the different colours were not essential to the permanence of the work, valuable though they were from the decorative point of view. Towards the end of the fifteenth century the craftsmen at Limoges in France, who did a good trade in enamelled shrines, caskets, croziers and other decorated metalwork began, in the enamelled pictures which they fitted into the work, to leave out the metal divisions altogether. The way in which they worked has been followed, with little variation, by enamellers ever since. It is this,—you wish to make an enamelled plaque with a design painted on it. Take a sheet of copper, or of whatever metal you are to use, measuring say, 3 inches by 2, size 6, and dome it up slightly in the middle, Fig. 284. It is well to make it turn rather quickly downwards near the edges, leaving all the centre in a gentle curve, like Fig. 285, not like 286. This may be done by running a burnisher repeatedly round the metal about $\frac{1}{8}$ inch from the edge, while the whole piece is held at an angle of 45° to the stake or bench. Then rub the burnisher across the plate from side to side in every direction until the centre is sufficiently raised. If the metal gets too hard first, you must anneal it. Instead of using the burnisher you can shape the plaque on a stake with the hammer alone, if you know how to

planish. But in any case it is well to anneal the plaque when you have finished shaping it. Next file the edge so that the plaque will stand quite truly on the surface plate. The file will leave a little rough burr all round the edge. Leave this, for it will help to keep the first coat of enamel on. If the plaque is not to be covered all over with the same enamel at first, but with a number of different colours to form a pattern, you must now draw the design on the metal. Transfer it with carbon paper and carefully scratch it in with a steel point. You may now boil the plaque in sulphuric acid pickle (water 20 parts, acid 1 part) or leave the plaque in the cold pickle for an hour. Next scrub thoroughly with a nailbrush both under and upper surfaces with pumice powder and water. Leave the plaque in a covered dish of clean water, and get the enamels ready.

Both sides of the plaque must be covered with enamel. To understand the reason for this, it will be well to consider first what would happen if the enamel were put on one side only. When the work was put into the furnace the metal would expand, and the fused enamel would settle down into close contact with it. When the work was taken from the furnace and cooled, both metal and enamel would contract. But the metal would contract much more than the enamel, for such is its nature. The result of this uneven shrinkage would be that a considerable strain would be put on the rather brittle enamel,—which would probably fly off, particularly if it were jarred in any way. Also, at the second and subsequent firings, the metal, being a better conductor of heat than the glass, would expand sooner, and again vary the stress on the glass. To avoid these dangers it is usual to cover both sides of the metal with enamel. The metal now, on cooling, cannot curl away from the enamel, as it did before. Nor can it contract more than the enamel, for it is gripped on both sides by it. It is, therefore, kept in its expanded state, and adapts itself to the new conditions —by stretching, as it were. That this is actually the case may be proved by measuring an enamel before and after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firing it, say, a dozen times. It will be found to have grown perhaps an eighth of an inch in six inches. For this reason the settings for large enamels should be made only when the firing has been completed. Inlaid enamels are sometimes backed if they show a persistent inclination to flake off. The doming-up of the plaque serves several purposes: it keeps the enamel on its underside from contact with the ground, it preserves the middle of the plaque from collapse, and its corners from curling up. The whole work is rather stronger.

Grind the enamels you are to use, wash them thoroughly, and put them into covered vessels with a little water. When washing translucent enamels always go on until the water which is poured off is quite clear from the milky tinge mentioned above, page 187. Fill the mortar with water, and wait a few seconds for the enamel to settle, then pour out the water. Repeat this as often as necessary. Do not throw away the sediment which will be found at the bottom of the vessel into which the water is poured. It is composed principally of finely ground enamel. It is quite good enough to use on the underside, or back, of the work. If an agate mortar is used the enamels require less washing: but agate mortars are expensive. Sets of little china pans, fitting one over the other, such as are sometimes used for water-colours, are useful for keeping small quantities of ground enamel free from dust. Ground enamel should always be kept wet.

Lift the plaque by its edges (do not touch the face) and lay it, concave side upwards, on a piece of clean blotting paper. Take some of the sediment from the washings, or any finely ground enamel which you wish to use up, and spread it evenly over the plate. You may add a drop or two of a solution of gum tragacanth or of saliva to assist in keeping it from falling off when the plaque is turned over, though if the work is handled carefully it will do without the gum. You may apply the enamel with a brush or spatula. It must be spread evenly, and be just thick enough to hide the metal. As a rule the enamel on

front and back of the plaque should be equal in thickness. Dry the backing by pressing a piece of blotting paper firmly upon it. Turn the work over and stand it on the table or on a dry piece of blotting paper: not a sodden piece, or some of the backing may come off. The design—scratched in before the plaque was cleaned—will still be visible. Fill it in with the proper colours, taking care to keep the edge of the ground enamel exactly to the drawing. If you put a drop of the gum tragacanth solution into the enamel on the plaque it will help to keep it together. Dry each patch of colour by touching its edge with blotting paper. Let it get nearly dry before you put the next colour up against it. The water will naturally run from the wet enamel into the dry, but you get a truer line between the colours if one is pretty dry first. You may, of course, mix the colours together as much as you like if they are all of the same hardness. The enamel should be spread evenly all over, but should not be thicker than is necessary to cover the surface completely. Do not let it get wet enough near the edges of the plaque to run on the table. When the plaque is completely covered, dry off the water with clean blotting paper. Lift it with the palette knife to the iron plate on which it goes into the furnace. Put both upon the top of the furnace to dry. Keep the work free from dust. When it is quite dry fire it.

When the enamel comes from the furnace and has cooled down, look it over carefully. Some of the back may have fallen off. If so, it must be repaired. Cracks due to the uneven support given to the metal may appear on the surface of the work. Scrape the metal quite clean at all bare places on both back and front, washing over the scraped edges with fluoric acid and afterwards with water, to avoid milkiness. Then repair the enamel and fire again.

If you give the copper plaque a coating of clear flux first, and then put the coloured enamels over that, they will show up much more brilliantly. Copper, with a coating of clear flux over it, looks a bright golden or a pink coppery colour

according to the composition of the flux used. Silver seen through flux looks like white satin. The colour of gold hardly changes at all. Any drawing on the metal, whether scratched in with a steel point, or drawn with a lead pencil, will show clearly through the flux. The surface of the flux may, however, be roughened, then washed over with fluoric acid to avoid milkiness in the colour (see above) and the design transferred to it. The coloured enamels are then applied in their proper places.

You have now the plaque with its first coat of coloured enamel fired on to it. The colours may require modifying, shading may be necessary; you may want to use some gold or silver foil to make a more brilliant patch of colour somewhere; you may wish to put an outline round parts of the design, or touches of gold. Some or all of these things may be necessary. Now, as already stated, enamels vary in their hardness, some requiring much greater heat to melt them than others. The hardest colours should therefore be put on first, the softer ones for a later firing. A plaque may be fired a dozen or more times, but the enamel put on for the later firings should not require heat enough to disturb the harder enamel put on first. So you must find out which colours require the most heat. To do this you take a little of each of those you wish to use and arrange them in a row on a clean plaque and put it in the furnace. Then you note carefully the order in which they melt as the plaque gets hot; then you can go ahead. First put on the foil. This is thin sheet gold, silver or platinum. Small pieces, or "paillons" of this are laid on the enamel and covered with transparent colours. They are used to brighten up the enamel where necessary, colours looking much brighter when fired over these metals than over copper. Pure gold foil can be bought from dealers in dentists' materials, a leaf 4 inches square costing 2*s*. If you were to put gold leaf on the enamel as it is, it would be likely to crinkle or bubble up owing to the air between it and the enamel. To overcome this difficulty, and to make it easier to handle and cut to

shape, it is well to stick the leaf between two sheets of gummed tissue paper. Then stab the leaf all over with a bundle of fine needles stuck in a cork. About 200 holes to the square inch will do. Now draw the design on the tissue paper and cut out the shapes with scissors. The paper may be soaked off in water. Stick the paillons down on the enamel with a little gum tragacanth. The dentist's gold, having been annealed before purchase, will lie flat when fired. Gold which is not annealed will crinkle. Silver foil must be treated in the same way as the gold. But, owing to its fusibility, its use is sometimes abandoned in favour of platinum. If the foil was now covered with enamel its edges would show up too strongly; they must therefore be shaded. Do this with iridium black and fire it. If this shading is satisfactory you may put finely ground (and washed) colour wherever necessary and fire that. For shading, however, you must use enamel ground finely enough to paint with.

Take a slab of plate glass, a foot square, and a glass muller, Fig. 279. See that they are both clean, and put a little of the colour you wish to use in the middle of the slab. You have now to grind it finely enough to use as paint. This will take time, but you must go on grinding till there is not a trace of grittiness to be seen in the colour where, near the edges of the slab, it is getting dry. Add a little water when necessary. The finely ground enamel must now be washed. It is not easy to do this without losing a good part of it. But most of the milkiness must be got rid of, or it will show up on the work. Keep that part which is nearest in colour to the enamel before it was ground.

To use finely ground enamel to paint with, take a drop of oil of spike lavender to mix with the colour. They will flow fairly smoothly from the brush if they have been evenly mixed. You may add a little fat oil of turpentine if the paint dries too soon in hot weather. But the addition of a large proportion of medium of any kind will tend to make the colour bubble up in the furnace, so use as little as possible.

Put in all the shading necessary. Then stand the enamel in a warm place to dry off as much of the medium as possible before the work goes into the furnace. Some of the shading sinks in each time the enamel is fired, so you must strengthen it where necessary. Black enamel, ground finely, turns rather grey, so if you require a very strong black line you should use iridium black. This can be bought ready prepared.

When all the painting is completed the gold may be put on. This can be bought in bottles from dealers in china colours, or the gold which is sold in shells at about a shilling each may be used. The liquid gold can be made from the following ingredients—

Lavender oil	900	parts
Gold chloride	100	,,
Bismuth subnitrate	5	,,
Chrome soap	50	,,

Wash the enamelled plate with spirit before putting on the gold. The latter must be well dried before firing. Not much heat is required to fix it. Gold from a gold shell looks brighter in most lights than the liquid gold,—which is similar to that so generally used on china goods.

It sometimes happens that an enamel curls out of shape during firing. It can be straightened in the following manner. Have ready two large, stiff palette knives. See that they are quite clean and free from dust. With one of the knives lift the enamel straight from the furnace on to a flat stake or smooth slab of stone. Instantly push down any projecting corners, using both knives near the edges of the plaque to press the work into shape. Hold the edges down till the red glow has quite gone from the work. The enamel will be quite soft when it comes from the furnace, but in a few seconds will have set hard—when any pressure would have disastrous results.

To remove a part of the enamel after it is fired is not so difficult a task as it looks at first sight. You can either

dissolve the enamel at the offending spot with fluoric acid, or you can boldly cut it out with a graver. In the latter case it is well to wash the spot afterwards with fluoric acid to avoid any subsequent milkiness in the colour.

Throughout all the work, absolute cleanliness of all the tools and materials is essential if you are to produce enamels free from specks.

It is not unusual to employ china colours for the final touching up of an enamel. But this practice is not to be recommended, as the colours have not the same quality as enamel itself. They are principally composed of mineral oxides, without flux. They may sink into the enamel and become incorporated with it, but as a rule they must be covered with a thin film of soft flux to protect them from the action of the atmosphere.

In the sixteenth and seventeenth centuries a large amount of work was done in grisaille on blue or black grounds. The copper was first covered all over with the dark-coloured ground. Then the designs were painted in monochrome, by successive layers of white enamel. Many coats of this were fired one over the other, till the light was sufficiently strong. The shading was given by the dark ground showing through the white. Sometimes little touches of colour were added, and gold. Much of the work shows wonderful technical ability, for the drawing and shading are excellent in spite of the difficulty of the medium. But, of course, all feeling for colour as such, is absent.

A ground of white enamel may be spread directly on to the metal, and fired. It is then ground level, and coloured enamels are painted over it. Much work in this fashion was done in the eighteenth century at Battersea and elsewhere. But, dainty though much of it is, it has lost the true quality of enamel,—the work being little different from china painting. White enamel is, however, sometimes painted over a portion of an enamelled plaque, shaded, and afterwards covered with a thin glaze of colour. The ground white enamel may be mixed with heavy paraffin oil as used

for lubrication, or with vaseline diluted with paraffin and painted on with a brush. Dry it very thoroughly before firing.

Enamelling being so much akin to glasswork, it is not surprising that the two crafts are sometimes combined. For instance, enamel colours are often used on glasswork. An unusual method is employed, however, in some of the enamels on the Ardagh Chalice in the National Museum, Dublin. A hemispherical blue glass bead has a recess carved or moulded in its surface. This recess is lined with a grey enamel and afterwards filled up with red. Other enamels on the same cup have a silver cell let into a glass or enamel bead, the cell being filled up afterwards with enamel of a different colour.

CHAPTER XXV

METAL CASTING

Cuttlefish moulds—Materials for moulds—The piece mould—The core—Casting a relief—Loam or casting sand—Flasks—Casting on the descending or the ascending principle—The pour—The vents.

THE casting of ingots of simple form is considered in Chapter II. Casting in cuttlefish-bone and by piece mould are dealt with here, a description of the waste wax-process being reserved for the following chapter.

Casting in cuttlefish is a process sometimes employed for the reproduction of small reliefs or other articles which have no undercutting. The model must not be in any soft material such as modelling-wax, though sealing-wax may be used. With these limitations it is a very convenient method for reproducing quite small work. Let us therefore consider it before we go on to the more important processes.

Take a sound cuttlefish bone and cut it across into two equal parts. One side of the bone is softer than the other. Grind the soft side of each piece quite flat on the rub stone. Flatten also one of the outer sides of the bone, near the thicker end. The reason for this will be given later. Fix three small wooden pegs with conical or pointed tops in one of the flattened faces of the mould. These pegs should be placed as far apart as they may conveniently be. When the two halves of the mould are pressed together the pointed tops of the pegs make marks which ensure the proper registration of the two pieces whenever they are again put together. Lay the pattern on one face of the mould, say, an inch from the top edge. Press the pattern a little way into the face of the bone. It will give sufficiently to allow this. Now place the second piece of bone exactly over the first,

and press it down on to the pegs and the model. Between hands and knees press the two parts firmly together. When the two faces have met, take a rough file and true up the outer edges of the mould while its two halves are in contact. Open it and lift out the model, a sharp impression of which will remain. Make a funnel-shaped opening from the impression to the top edge of the mould. This opening is called the "pour"—it is the way in for the molten metal. Make also a number of small grooves across the face of the mould, radiating from the impression. These grooves are called "vents." Through them the air escapes as the hot metal enters the mould. The grooves need not reach quite so far as the outer edge of the mould, or rather, they should not be wide enough to allow the metal to run right through them and escape. If they are as thick as a knitting-needle they will do. Next paint the face of the mould, where it will be touched by the heated metal, with a strong borax solution. This may be borax ground up on the slate as for soldering, or ground up with paraffin. When this has sunk in, go over the surface with a solution of silicate of soda (water glass)—half water and half silicate of soda. You may, if you wish, put on the borax and the silicate of soda solutions together, half of each. Their purpose is to toughen the face of the mould, so that it may stand the heat of the molten metal better. You may now replace the model very carefully in the mould, seeing that it registers exactly. But slightly oil its surface, or dust it over with French chalk first, lest it stick to the mould. Then put the second part of the mould in place and press the two halves together. This should give you a very sharp impression, see Fig. 287. Remove the model, tie the two parts of the mould together with binding wire, and dry thoroughly. Take a piece of charcoal and make a hollow in one face of it large enough to hold the metal which you wish to use for the cast. Tie this piece of charcoal against the flattened outer side of the cuttlefish mould, the upper surface of the two being level. Scrape a little

channel between the hollow in the charcoal and the funnel-shaped pour in the mould. All being ready, melt the metal in the charcoal hollow. Get it quite hot, and as soon as the brightness disappears and a film is about to form on it, tilt the block and mould so that the metal runs into the latter. You may open the mould immediately the metal has set. If, however, you heat the metal in a crucible, first set the mould in a box of dry (hot) sand.

Cuttlefish bone is unlike the other materials from which moulds are made in that the recess for the metal is made at once,—simply by pressure. When other materials are employed they are either painted or poured over the work in a more or less liquid state, or used in granular form and pressed against the pattern. With this exception, then, the qualities necessary for any material that is to be used for a mould are : (1) That it be of such consistency that it may be spread over the model in a very finely divided state—so that it may go into every crack, following the form very closely; and give a smooth surface where necessary. And (2) that it be able to stand the heat of the molten metal without melting, powdering or splitting. Moulds have to be heated to a bright-red heat to expel the moisture before the metal can be poured in, for any water present then will be converted into steam, which will force its way out somehow, even through the liquid metal. You may thus with a damp mould have a serious explosion, with molten metal thrown all about. The surface of the mould must be quite sound after this heating, or you will get a rough surface to the cast. In foundries where very large work is cast in sand, and it would not be practicable to dry the mould in this thorough way, the mould is "vented" for the escape of the gas by making an elaborate system of small holes through the sand with a wire. But in this work a very fine surface is not required. For fine metal-work it is of course necessary.

Now if the work is a relief, without any undercutting, it is possible to make one mould do for the front. But as

open moulds do not work very well, a slab of some material will be required for the back. Moreover if the model is not to be destroyed, and the work is in the round and undercut anywhere, the mould must be in several pieces. You could not otherwise remove the model. We will therefore discuss next the making of a piece mould. Let us suppose that you are to reproduce a statuette of a draped figure, Fig. 291. First look carefully over the model and decide where the joints in the mould must come. Each piece of the mould must be of such a shape that it is possible to withdraw it without any undercut piece catching. You must be able to withdraw each part of the mould in turn from the model, yet when all are in place the cast must be completely covered. Plaster casts of antique statues are generally sold with the seams which mark the position of joints in the mould still visible. An examination of one or two of these casts will teach you a good deal as to the planning out of the different pieces which go to make the mould. When a mould is in many pieces it is usual to make an outer or mother mould in two or three pieces to keep all the others in place. To return to our work.

One of the first things you have to decide is the manner in which you will arrange the pour (the place where the metal is poured into the mould) and the vents. In this case we will suppose that the metal is to enter the mould at the base. A suitably placed conical opening must therefore be provided when you make the mould. To settle the position and number of the vents you must, in imagination, follow the course of the metal and note every place where the air in the mould would be trapped by the molten metal. At each of these places you must leave an opening for the escape of the air. The metal will follow the air through the openings; so they must point upwards and extend up to the level of the pour. The seams in the mould will, of course, allow a good deal of air to escape. Having decided upon their position, paint the statuette all over with linseed oil, lard, clay water or some other

substance which will keep the mould from sticking to the plaster. Then take some modelling clay or wax, roll it into a rod and flatten it into a strip $\frac{1}{8}$ inch thick. Smooth it all along with the flat side of a knife, and cut the strip into bands $\frac{1}{2}$ inch wide. Take one of these bands and press it edgewise against the statuette, bending the strip all round the space which you have decided shall be covered by the first piece of the mould. The position of the first two pieces is shown by a thick dotted line in the illustration, Fig. 291. The first space should, as a rule, be near the base of the statuette if you are moulding it in an upright position; for this first piece will make a support for the next pieces higher up the figure. When you have bent the strip right round, see that it touches the figure all along without gaps. Support the back of the strip by small pieces of clay placed at intervals, then cover the rest of the figure with a cloth or wet paper to avoid splashing it. You are now ready for the moulding material.

Moulds are made in many materials: of loam, sand, plaster, brickdust, pumice powder, fireclay, soapstone, or of other ingredients in various proportions. Each moulder has his own preferences. Large works are generally cast in earthen moulds, *i. e.* of loam or sand, smaller ones in mixtures of the other materials. Let us suppose that you are to use "compo"— a mixture of plaster of Paris and bathbrick dust. The plaster should be such as will set quite hard in five minutes if mixed as described in Chapter III. The bathbrick dust is just the ordinary powdered bathbrick, used for cleaning knives. Half plaster and half bathbrick is a good proportion. For large works the proportion may be one-third plaster, two-thirds bathbrick. Plaster alone is liable to crumble away if made red hot, but if mixed with a little potassium sulphate, alum, soda or borax, it will stand the heat well. Cellini sometimes used a compo made from two parts plaster, one part powdered brick and one part powdered bone. Both brickdust and plaster should be free from lumps. When

you have mixed and thoroughly beaten up the liquid compo take a little in your hand and throw it on to that part of the figure which is within the clay band. Take care to leave no bubbles or gaps. Then as the compo gets stiffer, build up this piece of the mould till it is half an inch thick. For a large piece the thickness may be increased to three-quarters of an inch. Make the outer surface quite smooth. When the compo has set, lift the piece off and trim up all its edges. The compo will set hard in a few minutes, so do not mix more at a time than you can use.

Cut some shallow, conical holes at the edges to make "keys" with which the adjacent pieces of the mould may interlock. The projections on the one piece of the mould fit into the hollows in other pieces and keep all the parts from slipping out of place later on. Grease or claywash the back and edges of the piece just made—lard does well for this. Then replace the piece. Take another clay or wax band, and outline with it another space on the figure; the edge of the piece already made serving in place of a band on that side. Mix some more compo and fill in as before. When this piece has set, trim up all the edges except that which fits against the piece first made—that side should require no trimming. Cut keys in the edges. Claywash or grease, and replace the piece. Go on in this way till the whole figure is covered with small pieces which fit together like a puzzle. When the figure is thus covered in, make sure that the backs of all the pieces are smooth, that there are no undercut places which would prevent the mother mould from coming off. If there are any such recesses fill them up temporarily with clay. See that the backs of all the pieces have been greased. Then, following exactly the same method make the mother mould in two or three pieces. Afterwards remove it and lay the small pieces, each in its place, within one or other of the parts of the mother mould. If you now put these together you will have a hollow inside of exactly the shape of the statuette.

If this space were filled with metal you would have a solid

casting. But, except for very small articles, castings are generally made hollow. The thickness of a metal cast varies, of course, with the size of the work and with its form. Thus, for a statue standing on one foot the metal in the standing leg and foot would be made thicker than if the weight came on both. Three-eighths of an inch is about the thickness that a life-sized figure would be cast, though for such a work in the pose mentioned above, the thickness at the foot would be considerably greater.

A mass or "core" of a similar material to that of which the mould is made is therefore to be fixed inside, supported on iron wires, leaving a space of just the thickness that the metal is to be, between core and mould. To make the core. First take some lengths of iron wire and fix them inside the mould in such a way that they will support the core (when it has been poured round them) in the centre of the hollow. The wires must be fixed to the mould, so scrape small holes to receive their extremities. You will, of course, arrange that these come in places which will not disfigure the work much; for when the figure has been cast you may remove the core and the iron wires, plug up the holes left by them, and true up the surface of the work again. The wires being fixed, take some soft modelling wax, plasticine or clay, and roll it into slabs. Use a round bar for this, after the fashion of the domestic rolling-pin. The thickness of the slabs must be rather less than an eighth of an inch. Cut these slabs into convenient pieces and cover the inside of the mould with them, pressing the wax into the various parts without thinning the pieces. If you make it thin at any place, the metal which will later on replace the wax, will be thin too,—so try to make the wax layer of an even thickness, though you need not trouble to press it into every crevice or fold. Remember that you are settling now only the size and shape of the hollow inside the cast, so any parts which you wish to make solid in the metal you may fill up with wax now. But if you leave a fold in the drapery, say half an inch thick, and near it is a part

only one-eighth of an inch in thickness, you will probably get a cracked cast. The thickness should be pretty regular throughout. You have to see that you spread the layer of wax to such a thickness that the metal which replaces it is strong enough. You must leave the wires in, crossing the hollow space, inside the mould and wax, in various directions. See that when the various parts of the mould are put together the layer of wax joins neatly. Replace the mother mould and tie all together. Leave an opening at the centre of the base, or at some other part of the mould where it will not seriously damage the modelling, through which you may pour into the mould the material for the core.

Before mixing this material it is well to consider what happens when the metal, which is poured into the space now occupied by the wax, is cooling. It must contract on to the core very powerfully. Now if the core is hard and the metal thin, the latter will be likely to crack. Some moulders use the same material for the core as for the mould. But to avoid any danger it is well to make the core of a slightly yielding substance. Such a material is made from one part plaster of Paris, one part brickdust, two parts sawdust and a little alum, borax or soda. The sawdust will be burnt out when the mould is fired, and will leave the core porous. In mixing these materials put the sawdust and brickdust in the water first and get them soaked before you add the plaster. Beat the mixture up thoroughly with a spoon, and pour it into the hollow space inside the wax in the mould. When it has set, say, in ten minutes' time, open the mother mould. Lift out each piece of the inner mould, and put it in its place in the mother mould. Remove the core and all the wax. Next make the pour and the vents as described below. When these are completed, mould and core are ready for firing.

Some moulders make the core in another manner. They first soap the inside of the mould just as they would were they making an ordinary plaster copy. Then after fixing

the wires as described above, but omitting the wax lining, they fill the whole of the mould with the material for the core. They therefore on opening the mould find a replica of the figure they are to cast. This figure they pare down all over, taking off just the amount of material which they wish to replace by metal. The iron wires will, of course, keep the core in the centre of the hollow inside the mould during the subsequent operations. The drying of the mould is discussed on page 228.

When a thin, flattish casting has to be made, a relief, for instance, it is usual to arrange the work as shown in section in Fig. 288. A is the mould for the front of the work. B is that for its back. C is the cast itself. D is a large hollow at the top of the mould, filled at the bottom by the plug, E. F F F F are the inlets or "gates" for the metal, which flows from the hollow, D, when the plug is removed. G G G are vents to allow the air to escape. You will notice that they come from the top of each undulation in the shape of the upper surface of the cast—wherever, in fact, the air might be imprisoned by the molten metal. The inlets, F, run towards the lower parts of the undulations in the form. The air-vents should be as large or larger than the inlets. When the mould has been thoroughly dried, the molten metal is poured into the hollow, D. The plug is then removed and the metal flows through the various inlets to every part of the mould at once. With a thin casting this is essential, for if there were but one inlet the metal would be likely to set before it reached the extremities of the mould. You would therefore get a faulty casting.

Piece moulds are also made in loam or casting sand. The method employed, however, differs considerably from that for compo-work described above. It is well to have a large wooden tray on which to work. On this place the loam you are to use Mix a little water with it, and work it about with a piece of board measuring, say, 8 by 3½ inches. Put the heap of loam on the far side of the tray and scrape it towards you a little at a time with the board. Be careful

not to add too much water. The loam, when mixed, should just hold together when it has been gripped tightly in the hand. It will hold together if made much wetter, but you require it as dry as possible—if only it will bind. Next take a pair of flasks or casting boxes, Fig. 289. These are iron boxes without tops or bottoms. They are made in pairs; register "pins" on the rim of one box, going into holes or "eyes" in the rim of the other. Lay one flask with its register marks upwards on a piece of board or a small tray. Set both down in the large tray, and with a thin piece of board used as a shovel, fill the flask. Press the loam together lightly, and then lay your model or "pattern," which has previously been brushed over with French chalk, in a space you scrape for it. About half of the model should project above the top of the flask. Press the sand against the lower half of the model and level it off neatly all round, leaving the surface of the loam smooth and firm. Now dust over the model and the loam in the flask with parting dust. This is to prevent the loam which is afterwards put on from adhering to the other part of the mould. Pea-flour or lycopodium is used for this purpose. You have now to make of loam a sufficient number of pieces to cover the exposed half of the model; each piece to be of such a form that it may be withdrawn without binding in any undercut place.

Take a pinch or a handful, as the case may be, of the loam and press it against the model, building it into a neat little mass of the shape required. Each piece of the mould is to be dusted over, when completed, with the parting dust. A fork made from a couple of stout needles stuck in a piece of wood, is a convenient tool for lifting pieces of the mould without doing them any damage. See that the back of each piece is smooth before you finish with it. When the upper half of the model is, in this way, covered, you must make the cope, or case, or mother mould, which is to keep all the pieces in position. Put parting dust over all the pieces as they lie, and then put the second flask in position on the first. Fill it up to the

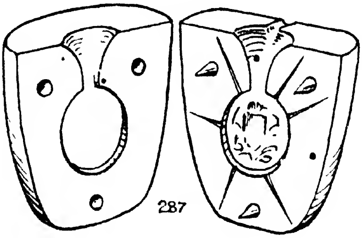
top with loam, pressing it round the pieces and against the sides of the flask. When it is quite tightly packed and full, level off the top of the loam with a stick. You may now turn the flasks over and scrape out the loam from the first. Lift this box off and remove all the loam which was in it. The parting dust will separate it definitely from that which belongs to the other box. Put fresh parting dust over the work, and proceed to cover the exposed half of the model with pieces as you did on the other side. When these are finished you make the cope or case for this side also. You may now separate the two flasks, lift out the pieces one by one and carefully put them in their places. Next bend and fix the irons which are to support the core. Dust over the inside of the mould with parting dust, and fill the cavity with loam, pressing it well against the irons. You have now a replica of the figure which is to be cast. Pare it down so that a space may be left between it and the surface of the mould the exact thickness you wish the metal to be. The pour and vents should now be made, and it may be well to consider for a moment the position of the former.

There are two principles on which the metal may be poured,—the descending and the ascending. In the former case the molten metal enters the mould at its highest point and runs between the core and the face of the mould to the bottom; then gradually filling up all the space provided for it, it finally reaches the top again. On the other hand when metal is poured on the ascending principle the pour is taken down to the lowest part of the mould before it enters the cavity, the metal thus filling the mould from the bottom and gradually rising to the top. If you think as to what happens inside a mould when the metal is poured in you will see at once that the ascending method is likely to be the better of the two; and experience proves that it is. When the metal enters the mould the air inside becomes very greatly heated and expanded. Now, it must all get out somehow, and vents are provided to carry it off. But on its way to the vents, if the casting is arranged on

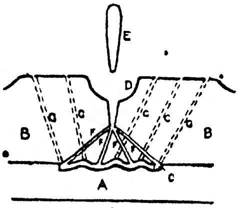
the descending principle, it must meet the stream of molten metal, which comes trickling over the core and face of the mould. Some of the air will be caught by the molten metal and carried along with it. Expanding very violently, it will bubble out through the molten metal, causing a great disturbance and perhaps injuring the surface of the mould. If, however, the metal enters the mould from the bottom all the air and the vents are above it. The air can then get out as fast as it likes without any danger of trapping or other interference. Also any scum or dross will float on the surface of the metal and be carried to the vents instead of being caught by the descending metal and carried perhaps to the face of the mould. Metal poured on the descending principle passes twice over the face of the mould; and has thus more opportunity of damaging it. But on the other plan, it enters the cavity from the bottom and flows gently up from the bottom without splashing or other disturbance. For these reasons it is well to pour always on the ascending principle. The pour or inlet is very often branched, so that the metal may reach all the principal parts of the mould at once. These branches are known as "jets" or "gates."

To return to our work: make the pour by scraping a passage from that end or side of the flask which is to be uppermost, to the lowest part of the cavity. It is generally possible to make this passage run in the loam along the crack which separates the two flasks. Branches may run from this passage to other parts of the cavity where necessary. Then make vents wherever there is any chance that the air may get trapped when the metal rises in the mould. The series of vents should be kept quite separate from the pour and gates. The mould should now be fired as described on page 223.

A wooden pattern is generally well varnished to keep the damp from getting at it. In casting from such a pattern dust it over with French chalk to keep the loam or sand from sticking. To remove a wooden pattern from the



287



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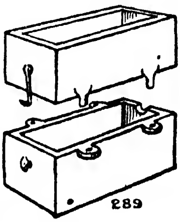

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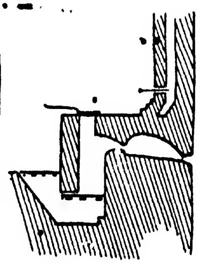

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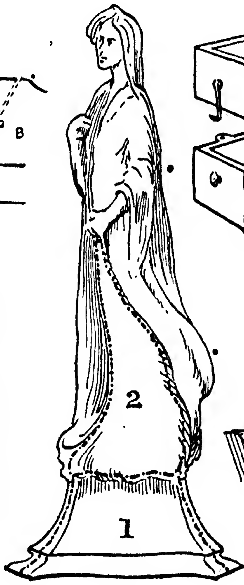

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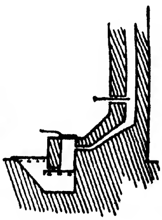


292

mould, stick a point firmly into it and give it a few taps sidewise with a pillar-file. This will free it from the mould, and you will be able to lift it out. Use French chalk and charcoal to face up. Some founders smoke the mould with a pitch torch and then replace the pattern for a moment, to ensure a good surface.

CHAPTER XXVI

CASTING (*continued*)

The "Cire perdue" or waste wax process—Composition of the wax—The wax model—The core—The pour, gates and vents—Materials for the final mould—Binding with wire—Cellini—Melting out the wax—Firing the mould—Furnaces—Fusing the metal—Fusible alloys—Pouring—Finishing casts.

CASTING by the "cire perdue," "cera perduta" or waste wax process has been practised from very early times. The method, roughly, is this. The model to be cast in metal is first made in wax. A mould, in one piece, is formed all round it. The wax is melted out and replaced by molten metal. When this has cooled the mould is destroyed and the metal casting exposed. For all except quite small works (which are cast solid) a core must be prepared as described in the last chapter; the wax model being made of the exact thickness required for the metal.

The first thing to consider is the wax. This must be suitable for modelling in, and its composition must be such that it can be melted or burnt out from the mould without leaving any residue. Plasticine therefore cannot be used. A mixture of beeswax and Venice turpentine may be employed, though many founders add resin, pitch, tallow, or other ingredients. Paraffin wax, as used for candles is quite good, but resin should be added to toughen it. Almost any mixture which will fulfil the two conditions mentioned above may be employed. Wax being semi-transparent, however, it is well to add some colouring matter to make it easier to see the modelling. Any dye may be used which will entirely burn away when the mould is fired. You should try a piece of the coloured wax before you employ it for any work. Put it in a clean, covered

crucible and burn it all away; if it leaves no residue it is safe to use. It should of course be made harder in warm weather, for a very sticky surface is difficult to work on; and however you prepare the wax model you are bound to work on it to some extent.

The wax being ready, the next thing to do is to prepare in it a cast from your model. For a large work this would be made in several pieces. Even in a small one, say of a man on horseback, it might be prepared in several parts which would be afterwards joined together. For this wax cast you will require a piece mould, made in plaster as described in the last chapter, or a gelatine mould. A quite small work may be cast solid, so all you have to do yet is to fill the mould with melted wax and wait for it to set.

For cored work, however, you must proceed on a different plan. Inside the mould you have to spread an even layer of wax of the exact thickness you wish the metal cast to be. You may wish the wax, and therefore the metal, to be thicker in some parts than in others, see page 213. You must therefore spread a thicker layer of wax in those places.

There are several different ways in which you may prepare the wax model, much depending on the shape of the work. One plan is that in which the wax is poured into the mould round the core. Cellini used to work in this way sometimes. He first greased the mould with bacon fat. There is, however, a small chance that the wax may not penetrate to every part of the mould, especially if the latter is not made fairly warm first. For the complete system of vents, which will be arranged later, is not provided for in the plaster mould; and the wax may be chilled by contact with the mould before it has penetrated everywhere; or the air may be trapped in places and make the wax faulty. Another plan is therefore generally adopted. In this, molten wax is painted into the two halves of the mould to make sure that the whole surface is properly covered. Then the two halves are put together and the whole mould filled with melted wax. After a few seconds this is emptied out,

leaving another layer of wax over that first painted in. This operation is repeated again and again until there is a sufficiently thick layer of wax inside the mould. The mould should then be put into a cool place, so that the wax may be properly set before it is removed. It may then be kept cool in a bowl of water. If the work measures but a few inches in height and is not an awkward shape it will be safe to handle without a core. But for larger work it is well to make the core before the wax is removed from the mould. Holes may be cut through mould and wax to take the iron wires which are to keep the core in position when, later on, the wax itself is removed. If the wires had been fixed before the wax cast was made they would have been coated with wax and would not have held the core firmly. The wires may be arranged to end in a line with the seams of the mould. A sufficient number should always be provided to hold the core safely in whichever direction the mould may be turned.

Mix up the material for the core as directed on page 214, and pour it inside the wax in the mould. When the core has set remove the mould. If you had removed the wax from the mould first it might have been distorted by its own weight; and the pressure of the core might injure the wax if the latter had not the support of the mould when the former was setting. The irons which penetrate the core will be seen projecting from the wax in all directions. You must now remove all the seam marks and give the final touches to the modelling. Another plan is that in which the irons to hold the core are fixed after the final touching up of the wax, holes being drilled through the wax into the core, and the wires pressed into them. The outer extremities of the wires are firmly gripped later by the new mould which is to be formed round the work. But of course, if the work is large, irons may be necessary from the first to support the weight of the core.

When you have finished tidying up the modelling you must fix the pour, the gates, the vents, and any lugs required

underneath the work by which it may be fastened upon its base when completed. These lugs are just lumps of metal into which screws may fasten. They are all made from the same wax as the model. Make a number of rods or threads of wax ready for use. Then decide where you will have the pour and gates. Remember that each gate or vent which you make will be replaced later on by a rod of metal fixed to the cast. These rods will have to be sawn off, and the surface of the metal chased up again; so do not fix them in places where they will damage the modelling much. At the same time you must have a sufficient number of gates to allow the metal to get to every part of the work before it sets.

Let us suppose that you are to cast a small standing figure with wings, the tips of which point downwards, clear of the legs; the figure resting on a small wax base: the metal to be poured on the ascending principle. For convenience in working it will be well to prepare the mould with the figure standing on its feet, and afterwards to turn it upside down to pour the metal in. The three highest points of the figure as it stands, are the head and the tops of the wings. It will be well to let the metal enter the mould at these three places; so take thickish rods of wax, warm their ends and stick them on. Take care to put them in places where they will not injure the modelling much. Bend the rods of wax well clear of the figure and unite the three into one. This rod must extend to below the wax base of the figure as it stands: it is the pour. Now you must fix the vents. One or more will be required at the tip of each wing, others at the hands, and at the lowest parts of the wax base. If you follow in imagination the course of the metal from the head and the top of the wings towards the feet, you will be able to see where the air might get trapped. To every such place attach a thread of wax of suitable thickness. The mould will be turned upside down for the metal to be poured in, so that the pour and vents, which now come down below the feet of the figure,

will be uppermost then. There will be a great deal of heated air to escape, so put plenty of vents. All those rods and threads of wax, which represent the vents, should be bent well clear of the figure and reach lower than the wax base. They may combine here to form one or more large vents. The vents must be kept quite separate from the pour and gates. When all these have been fixed you are ready for the final mould.

Every founder has his own special material for moulds. They generally have finely ground loam as their basis, with a proportion of some non-fusible substance to make them stand fire well, and some other substance to bind all together. There is no reason, however, why the plaster and brickdust compo given in the last chapter should not be employed. However, for a loam mould, take some loam and grind it extremely fine in a mortar with paraffin. Grind also as finely as possible some burnt fireclay (old crucibles, if you have any), ganister, emery or almost any other fire-resisting substance. Mix these two powders together, and, using them as a paint, go carefully over the wax model with a brush. Many founders add some binding substance to this loam mixture—white of egg or a solution of cow or horse dung. For the second coating add fine sawdust and finely shredded asbestos to the mixture. The use of sawdust as an ingredient in furnace casings, moulds, etc., is largely due to the work of Mr. Thomas Fletcher of Warrington, the well-known maker of gas-heating appliances. The sawdust is, of course, burnt out later on, leaving a very strong, light and porous mould. The fibres of asbestos tie the other materials together. The Japanese use boiled paper instead of asbestos fibre. Their paper is made from the inner bark of the mulberry tree. It is the only long-fibred paper known,—that made from rags is much shorter in the grain. The outer surface of each coat should be left rough, so that the next may hold well to it. Each coating should go over all the surface of the model, the vents, the gates and the pour. The materials for the outer coatings need not be so finely

ground. Let each coating get fairly dry before the next is painted on.

When the spaces between the model and the vents and pour have been filled up, and the mould has grown strong enough to allow it, wind binding wire round and round the whole mould. This will do much to strengthen it against the expansive power of the metal. Then add a few more coats to the mould. The thickness for the mould may be ¾ inch for a mould a foot high, and thicker in proportion for larger work. Before the metal is poured in, the mould will be packed round with sand, as described later.

A number of different receipts have come down to us from the old founders, and one may get good hints from them. Benvenuto Cellini, describing how he cast the Nymph of Fontainebleau, says: "I pounded up some ox bone, or rather the burnt core of ox horns. It is like a sponge, ignites easily, and is the best bone you can get anywhere. With this I beat up half a similar quantity of gesso of tripoli" (we should use plaster of Paris), "and a fourth part of iron filings, and mixed the three things well together with a moist solution of dung of horses or kine, which I first passed through a sieve with fresh water, till the latter took the colour of the dung." He gave the wax model three coatings each of the thickness of the back of a table knife, letting the mould dry between each coating. Then he gave it several coatings of clay, or loam, in which rags had been left to rot for some months. Another mould he made of loam well dried and sifted, mixed with rotten rags and a little cow's dung. These he beat well together. Then he took "tripoli such as jewellers use to polish their gems with," powdered it up very finely and painted it over the model. After this he used the loam.

To cast a figure Cellini proceeded in the following manner. He first made a piece mould in plaster. Inside this he spread a layer of wax of the exact thickness he wished the metal to be. (It might be thicker in parts, where required for strength.) When he had covered the inside of the

mould in this manner, he made an iron framework to support the core. The extremities of this framework rested in recesses cut in the piece mould. The core was then built up round the irons. The material used was clay, or loam, in which rags had been left to rot for some months. Two-thirds clay to one-third rags was the proportion employed. When the core filled the entire space within the wax, Cellini wound thin iron wire round it from head to foot, and baked it. The core was given a final coating with a mixture of powdered bone, brickdust and loam. It was then fired again. The layer of wax was now removed, and the surface of the mould greased with bacon fat. An opening was made for the pour, and a number of vents—to prevent any trapping of the air. The core was placed inside the mould and well melted wax poured in. The mould was opened after a day or two, and the final touches given to the modelling of the wax figure. The pour, gates and vents were now made in wax.

When casting his figure of Perseus, Cellini arranged the pour so that it ran down at the back of the figure to both heels, with many gates. He kept the figure in the vertical position all the while. In fixing his vents, therefore, he was careful to lead them all downwards; he was thus able to melt the wax out without reversing the mould. The vents were afterwards connected to vertical pipes, which rose to the level of the top of the pour. In the case of his Perseus, to make sure that the core should not shift in the mould, and to provide spaces through which the core might be afterwards removed, Cellini cut away the wax at a number of places in the flanks, shoulders and legs. At these points, therefore, the outer mould would be in contact with the core, and support it firmly. The outer mould was made as described above, and bound round with hoop iron. The wax was melted out in a gentle fire. The whole mould was then thoroughly fired. It was afterwards put into the casting pit—a deep hole dug in the floor, opposite the mouth of the furnace. The vents were carried up to the floor level by earthen pipes, and the pit filled up with tightly rammed

earth. A walled channel was built from the furnace to the pour, and a fire kept alight in the channel till it was baked thoroughly dry.

Cellini made both core and mould sometimes from a mixture of plaster, burnt bone and pounded brick. This, he points out, is a much quicker method of making a core than that above described. But unless you are sure of the plaster it is an uncertain one. For poor plaster, or plaster which has been kept too long, will not set firmly. He very properly advises you to try your materials first. He used one part of plaster to an equal portion of pounded bone and brick. The core was made by pouring compo (round the irons) inside the wax lining of the piece mould; the core was then bound round with iron wire and given a final coat of the compo. Then it was fired. The final wax cast was next made as described above, and the compo mould formed round it. When this had reached a thickness of about 1½ inches it was strengthened with iron bands, given a final coat of compo and fired.

The mould having been formed round the wax model in one of the ways above described, the wax must be melted out. If the work is small the mould may be turned upside down, and heated in an oven until all the wax has run out. For a larger work a rough kiln must be built round the mould and a fire kept up till all the wax has been removed. The mould is then allowed to cool, and any drain holes made for the escape of the wax, which will not be required afterwards for vents, are carefully stopped up with the same material as that of which the mould is made. The fire is then lighted again. And, in any case, whether the mould be large or small, of loam or compo, the firing must be continued till the whole mould is a good cherry-red colour. In this manner the mould is hardened, fusible materials are burnt out of it, and every trace of moisture expelled. It should be hot enough to set fire to a piece of paper or tarred string let down into the pour. For small castings the metal may be poured while the mould is red hot.

But in large ones it is first allowed to cool down, for when there is so much metal there is no likelihood that it will get chilled; and there would be danger of melting the face of the mould if that were red hot when the metal entered.

The mould having been fired, it is usual to bury it in a box or pit, and to tightly pack it round with earth,—which should not be damp. If the vents are not entirely within the mass of the mould they must be carried up to the top of the box, or to the ground level, as the case may be. Remember that the molten metal will follow the air through them, and it may rise as high as the level of the metal in the pour, so the pipes used should be quite dry, and any joints carefully looked to. A hollow or basin should have been formed at the head of the pour, for convenience in getting the metal into it. Some founders make a large enough hollow to hold all the metal required for the work. They fix a fireclay or plumbago plug to the pour, and withdraw it when the basin has been filled. The molten metal then cannot carry any air bubbles down with it; nor can any dross enter the mould, for it will naturally float on the top of the molten metal. The plug must be tall enough to project above the top of the hollow, to enable it to be lifted out with the tongs when the basin is full.

For small castings, weighing anything up to 12 lb, one of Fletcher's injector furnaces is the most convenient. A gas supply pipe of about ¾ inch internal diameter and a No. 5 foot blower are necessary. These furnaces are simple cylindrical casings of specially prepared fireclay, in which the crucible stands. The jet enters the furnace through an opening near the bottom and the products of combustion escape through a small hole in the lid. For larger work than this a draught furnace of the ordinary foundry pattern is generally employed; although gas furnaces of much larger size are sometimes to be met with. The foundry furnace is arranged like Fig. 292. It has at the bottom an iron grating through which the air comes, and the ashes fall. The crucible is supported on a stand which rests on this grating, a handful

of ashes having been previously thrown on it to keep the crucible from sticking. The entrance to the chimney is at the side or back of the furnace, a couple of inches above the top of the crucible. It is provided with a damper, which can entirely close it. A lid covers the top of the furnace. The crucible, ready filled, and covered by its lid, is placed on the stand inside the furnace. A few shovelfuls of red-hot coke are thrown round it, and the remainder of the space inside the furnace, up to the level of the top of the crucible, is filled up with broken coke. The lid of the furnace is replaced and the damper drawn. A series of these furnaces is built along a wall of the foundry; several being heated at once when a considerable amount of metal is required for one cast.

Of much greater power is the reverberatory furnace, Fig. 290, which is used when a very large amount of metal is required,—in casting a statue, for example. No crucibles are employed in this furnace, the metal resting on the floor of the furnace itself. The floor slopes down to the outlet hole, which is closed with a plug till the metal is required. The fireplace is at one end of the furnace and the chimney at the other. The flames pass from the fireplace over a low wall and strike against the roof of the furnace. This, which has a flattened dome shape, drives them down on to the metal before they reach the chimney. A bricked channel, thoroughly dried, must run from the mouth of the furnace to the pour in the mould, where it ests in the casting pit.

The metal must be our next consideration. Platinum cannot be melted with the ordinary gas blowpipe or in the furnace; a supply of pure oxygen, as in the oxyhydrogen blowpipe, being necessary to fuse it. Gold and its alloys cast well, as do fine and standard silver, see Chapter II. The metal or alloy is generally put in a fireclay crucible with a little powdered borax on top. Pieces of charcoal should be put in also. Powdered charcoal is likely to get into the cast and injure it. More metal can be added when that

put in first settles down in the crucible. Add a tiny piece of zinc to the gold or silver before pouring. Copper does not cast well, so it is generally alloyed. The addition of a little tin, zinc and lead to the copper, produces an excellent alloy. When copper is alloyed with a small proportion of tin the result is known as bronze: if alloyed with zinc it is known as brass. But there are so many alloys in which copper predominates that many people call them all brasses. The ingredients of a few well-known alloys are to be found on page 303. Bronze composed of copper with a small percentage of tin does not flow so well as a similar alloy to which a little zinc or lead has been added; so the bronze used by founders frequently has 3 or 6 per cent. of both tin and zinc and perhaps 1 per cent. of lead. In making these alloys the copper should be melted in a crucible under a layer of charcoal. Pearlash, cream of tartar or even common salt is used as a flux. They are all better than borax. The tin, or tin and zinc should be warmed to near their melting point and then added to the copper. The mixture should be thoroughly stirred: many founders do this with a stick of green wood. Casts are frequently made in lead, zinc or in one of the fusible alloys; these casts being afterwards chased up and used as patterns for casting a number of replicas from. Lead or zinc casts can be made in plaster moulds, thoroughly dried. The surface of the mould is sometimes smoked with a pitch torch to obtain a finer surface.

Thirteen parts lead, 3 parts zinc and 6 parts bismuth make a useful alloy for small castings. Very sharp casts may be obtained with it, as there is considerable expansion of the mass on cooling. Type-metal acts in a similar manner and gives good casts.

Spon gives a list of alloys having very low melting points, as follows :—

"(1) 8 parts bismuth, 5 lead, 3 tin. Melting point 202° F. (94·5° C.).

(2) 2 parts bismuth, 5 lead, 3 tin. Melts in boiling water.

(3) 5 bismuth, 3 lead, 2 tin. Melts at 197° F. (92° C.).

(4) 15 bismuth, 8 lead, 4 tin, 3 cadmium. Known as Wood's patent, has a brilliant metallic lustre, does not tarnish readily and melts between 150° and 160° F. (65½° to 71° C.).

(5) 5 volumes each of bismuth, lead and tin, with 4 of cadmium, form an alloy which is quite liquid at 150° F. (65½° C.).

(6) 4 volumes each of bismuth, lead and tin with 3 of cadmium. Fuses at 153½° F. (67½° C.).

(7) 2 volumes each of bismuth, lead and tin, with 1 of cadmium, or 1 volume of each of the 4 metals fuses at 155½° F. (68½° C.).

(8) 1 part tin, 1 lead, 2 bismuth. Melts at 200° F. (93·5 C.).

(9) 15 parts bismuth, 8 lead, 4 tin, 2 cadmium. Melts below 140° F. (60° C.).

N.B.—All alloys containing cadmium are liable to undergo rapid oxidisation in contact with water."

Although lead and tin alloys are very generally melted in an open iron ladle it is wasteful to do so unless the surface of the molten metal is covered by some substance which will exclude the air. Linseed or sweet oil will do quite well. Otherwise it is better to use a deep, narrow vessel, for molten lead oxidises very rapidly in contact with air, so the less surface exposed the better. The dross which forms on the surface should be removed with an iron spoon and the metal poured immediately afterwards.

Copper alloys should be stirred well before the crucible is removed from the furnace. Some founders do this with a piece of charcoal gripped in the tongs, others stir with a green stick. The crucible tongs have curved jaws which securely grip the crucible so that it may be lifted safely. The molten metal is now skimmed to remove any dross or

floating charcoal, and tipped into the basin-shaped hollow at the head of the pour. If there is no such hollow provided, it is well to keep back with a strip of iron any dross, flux or charcoal which may yet float on the metal. The metal should be poured in very steadily, that is to say, in a continuous stream without any stoppages. The metal should run in quietly, without bubbling or welling up, and gradually rise in the vents. Continue to pour steadily until the metal ceases to run down. Leave a good mass, or "head," of metal in the pour. Its weight will force the metal below it into all the hollows of the mould, if the vents are working properly. If all has gone quietly the head of metal will go a little hollow in the centre as the metal cools. If however, the metal bubbles and splutters when you pour, either the gates and vents have not been properly constructed or the mould is damp. In either case the cast will probably be damaged.

The mould should be broken down as soon as possible after the metal has set. But it must be done carefully, for the heated metal is easily injured. With a hack saw cut off all the gates and vents, for they are now represented by rods and threads of metal attached to the cast. Saw them off as close to the work as possible. If the core is to be removed, rake it out through any available opening. In casting large bells it is usual to rake out the core before the metal has had time to cool down, for the shrinkage of the bell on the core might otherwise cause cracks in the work.

The irons which supported the core should be cut out. The whole work is now scrubbed clean; and afterwards, if small, boiled out in pickle. Casts made in the fusible alloys above mentioned cannot, however, be pickled in hot solutions. The holes made by the irons are now to be plugged up. They should be tapped, and pieces of metal screwed into them. All rough parts are now gone over with files and riffles, and finally with chasing tools. After tapping the lugs for the screws which are to hold the cast on to its base if required, the work is ready for colouring.

CHAPTER XXVII

CONSTRUCTION

Hollow handles—Compound mouldings—Fitting moulding to a tapering vessel—The folding iron—Square and round trays—Buckling in sheet metal—Fixing a tablet to a wall—Inkpot tops.

A NUMBER of points of construction are dealt with in this chapter.

The building up of the hollow handle for a flagon, Fig. 293, is effected in the following manner. Cut a strip of metal the full length of the handle—measured round the curve, and wide enough to make the inside part, D E F. The handle is, of course, rounded at the inside, flat outside, and tapering towards each end. The strip tapers in a corresponding manner. The outside, D F, is made from a separate piece. Bend the strips to the proper curve, A B C, and solder a piece of thick brass wire between A and C. You must use hard solder. The soldering will anneal the strip. Now find a stake the end of which will fit into the curve D E F. A mandrel may do; or the pointed bickiron; or perhaps the rounded side of the head of the raising hammer. Held in the vice, a hammer-head makes a very efficient stake. On whichever tool is most convenient drive the edges of the strip round into the curve. It is necessary to stretch the edges to get them round, so you may have to anneal the work before it will go far enough. Watch carefully that you keep the axis of the work straight. Planish the handle all over before you remove the brass stay. Then mark carefully the profile of the edges G from both sides. Cut and file the edges true. And, holding a straight-edge across them, see that it is at right angles to the handle at every part of the curve G when looked at from either top or bottom. When you are quite satisfied with this and with the curve

of the handle from every point of view, bevel off the inside corner of the metal all along the edges G. Now take another strip of metal, D F, as long as the handle, and a little wider than the gap between the edges G. Lay it flat on the bench and run the burnisher or a round-faced hammer up and down the middle of it several times. This will give it a very slight curve from side to side. Anneal the strip, and bend it round the handle, the convex side of the strip to be outside. With a steel point scratch a line on the strip against the edge G. Cut and file the strip to the exact width required (D F). Then bevel away the inner corners of its long edges. When the strip is put into position against the curved piece D E F, it should fit exactly, and the joins come neatly at the corners D and F. Of course you may, if you like, omit all the bevelling. The join in that case will not come quite at the corner. Borax the two long joins and tie the pieces together. To make sure that the two pieces are properly joined all along it is well to solder only two or three inches at a time, temporarily bending back the remainder of the piece D F to allow room to place the pieces of solder inside. Take care not to buckle D F in so doing; nor must you allow the solder to flow along any part of the joint which is sprung or bent open at all. To make sure of this, do not allow the metal to get red-hot except in that part of the joint in which the two parts are in close contact. You can in this way gradually solder the handle from end to end. The thumb-piece, if there is one, can now be made and soldered on, as can the little pieces which close the ends of the handle. Do not omit to drill a little hole in the handle somewhere where it will not be seen, to allow any confined air to escape.

To build up a compound moulding, say, for the base of a chalice, of which Fig. 294 is the plan and Fig. 295 the enlarged profile. The principal difficulty will be to keep everything concentric and true in the fitting and soldering, so too much care cannot be taken in making each individual piece true in itself. The plan shows four curved pieces

and four projecting corners. You will require a straight piece, long enough to produce the eight little pieces for the corners; and four rings for the curved parts. Rather more than half of each ring will be required, so in this case the segments cut away will be useless. Suppose you make the rings first. The lowest part of the moulding is formed from a thick strip bent flatwise into a circle. Do this as described on page 139. Cut each ring from the strip when it has been bent to the curve and trued up on the T-stake. When the rings are soldered you can turn them true on the lathe. If you have no lathe, file them. Take strips of metal for the next part of the moulding, H, Fig. 295. Join their ends and shape the rings thus made on a suitable stake. Collet hammers Figs. 133, 134 will be found very useful for this part of the work. You will notice that you may save yourself a good deal of hammering if, instead of using a straight strip of metal to turn round into the ring H, you use a curved piece, set out as described on page 249. A curved piece of metal so set out can be made, it forms part of a cone, as shown in J, Fig. 296. It is obviously easier to make H from a ring shaped like J than from a straight one like Fig. 297. You may find that a small hammer held in the vice will make a suitable stake for doing some of the shaping on. When the rings are correct in shape, wire them on to the moulding already made and solder them there. Take care to keep the joins in each ring and band in that part of the circumference of the circle which will be cut away when you are fitting the various pieces together to form the foot of the cup. But though you keep the joins near together do not let them come exactly one over the other, they might slip and give trouble. When you have completed the rings try them in the lathe, and true them up if necessary. Each ring should stand exactly the same height.

Now you must take in hand the straight pieces for the foot. The thick strips may be filed to shape, or bent round into a ring edgewise—not flatwise as for the circles—soldered

and turned to the proper section on a big chuck. Afterwards you must cut through the join in the ring and straighten the metal out. It will be a long, straight strip of the correct shape for the lowest member of the moulding. Build up the straight moulding as you did the rings, and take care that when finished it stands just the same height as they do. Cut the corners in a suitable mitre block, but see that the moulding stands level when you are cutting it. Fit the joints carefully, standing the pieces of moulding upon the tracing, on a surface plate or sheet of plate glass, to make sure that everything is level. Solder each corner separately, then stand it on the tracing again as before, and mark where it is to join the circles. Take the circles also, and cut out from each the part that is not required. Fit corners and circle together carefully. Finally solder each circle to its right or left hand corner, and the four pieces together. Rest the work, when soldering it, on a very level surface; but put broken pieces of piercing saws between the work and the slab, otherwise you might have some difficulty in getting it hot enough. The complete bottom moulding is now ready to be fixed to the foot of the chalice. Remember that if you boil the work out after each soldering and put rouge, loam or whiting on the joints which have been already soldered, there will be little likelihood of their coming apart at subsequent firings.

When a strip of moulding has to be applied to a tapering shape like Fig. 298, you will have considerable difficulty in getting it to lie flat against the work all round, unless you bend the moulding to a suitable curve first. If, however, you draw the elevation of that part of the work against which the moulding is to fit, and set out the curve as described on page 249, then a moulding bent to that curve, as in Fig. 299, will, when bent into a circle, fit closely against the form shown in Fig. 298.

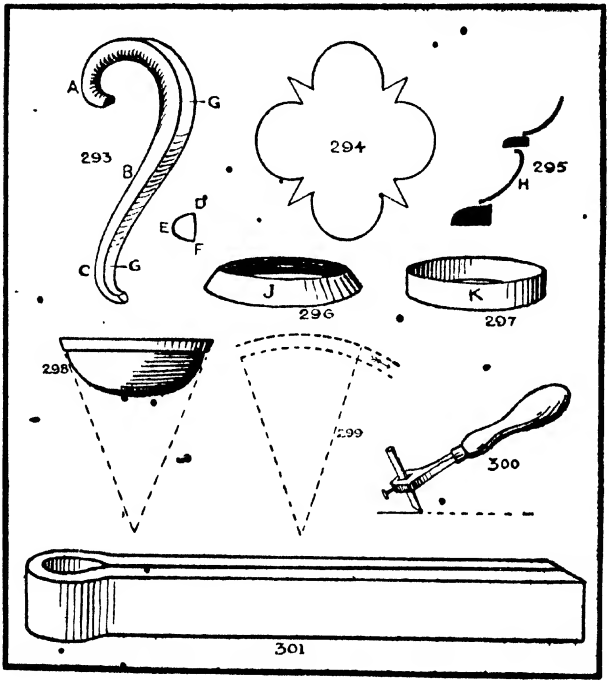
A tool which will be found extremely useful is that known as the folding iron, Fig. 301. It is made from a strip of iron or steel measuring, say, 3 feet by 1½ inch by

$\frac{1}{2}$ inch. This is folded in two, being forged thinner at the fold, so that its two halves may be easily sprung apart sufficiently to allow a piece of sheet metal to be slipped between. Suppose you have to turn up the edge of a rectangular tray, or to bend a piece of metal round to make the four sides of a box. Mark with pencil where the bend is to come. Then slip the sheet between the two halves of the folding iron and bring the pencil line level with the top of the iron. Grip the latter in the vice. If the ends of the iron gape apart, grip them also in the jaws of a hand-vice. You may now bend that part of the tray which projects above the folding iron right down on to its top surface, and tap the corner or edge down smoothly with mallet or hammer. The two long sides of a tray may be bent thus. The two shorter sides must be bent down over a flat, square-edged stake if you have no short folding irons which are available for the work.

When a rectangular box is made from sheet metal the latter is sometimes scored deeply at the places where the folds are to come. For this, the tool shown in Fig. 300 will be found convenient. It consists of a handle, a shank, and a small steel cutter which passes through a hole in the shank and is kept in position by a set screw.

The repoussé ornament on a circular tray is often worked before the centre of the tray is sunk. The repoussé work stretches the metal considerably, with the result that it is warped and buckled a good deal. It must be made true again before the other work can proceed. To remove a buckle in a piece of metal: lay it upon a flat bench and take a mallet, the head of which is in section like Fig. 198, that is to say, flat, with the corners rounded off. Now a buckle in a sheet of metal means that some part or parts are stretched more than the rest. It is very difficult, almost impossible, to contract the part that has been stretched, but it is possible to so expand the parts near it that the sheet of metal may lie flat again. The metal may have been stretched either at the edge or nearer the middle of the sheet. If the

edge is stretched, some part of it will not lie flat however much you press it, for it will always rise in some other place. Notice where the sheet looks tight,—a part near the stretched place which does not move about, whichever part of the stretched edge you press down. You must work with a good deal of judgment, but you must give that tight place



a few good blows, a dozen perhaps, to stretch it. As it stretches it will relieve the edge and allow it to go down.

Remember that if an edge is stretched you must on no account hammer it any more, you would only stretch it still further. Hammer the part that looks tight, and that will relieve the stretching. Now, on the other hand, your piece

of metal may have been stretched in the middle. Its edge is tight, and must be expanded. Where the sheet is stretched in the middle it will rock on the bossed out part, or, if you turn it upside down and press it hard, stand up in the middle though the edges are rightly pressed to the bench. In this case hammer round the edge. Perhaps the most difficult buckle to deal with is that in which the metal is twisted like a screw—the right hand far corner and the left near corner going up, and the left far corner and right near corner going down, or vice versa. A buckle of this kind means that the work is tight in the middle and must be stretched from the centre and in lines parallel to the diagonals. When nearly correct don't give a blow too many; but see the effect of each one. It may be necessary to anneal the work.

To return to the round tray. When you have got it flat, see that the edge is truly circular. Then wire it, if it is to be wired. Mark round with the compasses the line within which the sunken part of the tray is to come. Use a hammer like Fig. 137; its face measures about 1¼ inch by ⅞ inch. You may sink the hollow in the tray by holding it on a flat stake and hammering the metal so as to stretch and sink it all round, just within the compass line. While hammering so you tilt the far edge of the tray upwards and hold the compass line just over the front edge of the flat stake. Hammer all round quite evenly and go on until a sufficient depth has been attained. You finish this sinking by planishing the hammer-marks smooth, using a flat block of hard wood as a stake. The sunken part of the tray should turn downwards quite suddenly from the rim, so to hammer this part the tray has to stand almost vertically on the stake. If the weight of the tray is too great to manage easily with the left hand, have a pulley fixed above the bench. At one end of the cord put a weight, at the other tie a hand-vice. With this you may grip the far edge of the tray and so relieve the strain on your wrist. A small tray may be sunk in a hollow hammered in a large block of lead; the shape of the hollow being such that part of the

finished tray could lie in it, if necessary. Planish the tray on the wood block as above.

There are several ways in which it is possible to fix a tablet to a wall. If the work is light and you may screw through from the front of it, it is usual to let into the wall plugs into which the screws may go. To drill a hole in a stone wall, take a well tempered chisel, 9 or more inches long, and, after carefully marking the place, give the chisel a series of smart blows with a hammer or mallet. Rotate the chisel a little after each blow, and you will find that the chisel point gradually splinters a circular depression in the stone. Go on till the hollow is deep enough, and enlarge it a little at the bottom—dove-tail fashion. Then take an oak peg, thoroughly dried in an oven, and drive it into the hole. Saw its head off afterwards, flush with the wall.

With a heavy memorial it is usual to provide metal rods projecting several inches from the back of the work. These rods are roughened all along and slightly expanded at the extremity. Holes are bored in the wall as described above; the memorial tried in its place, and afterwards removed. The holes are then all filled with Portland cement. The memorial is again put into position, the rods pushing their way through the cement. The work is shored up till the cement is dry. It grips the rods very strongly, making the work quite secure.

The metal tops to glass inkpots are fixed on with plaster of Paris. They may be removed by soaking the tops in a strong solution of lump sugar and water.

CHAPTER XXVIII

SETTING OUT

Tools—Transferring drawings to metal—Measurements—Various geometrical problems—Setting out inscriptions—Rectangular ring for small work.

IN this chapter are given a number of hints and rules which may be useful in the setting out of work.

The tools required for work on paper are—

1. A drawing board. This should be square at the corners, the sides should be absolutely straight and the surface level. The size must depend on the kind of work you are doing.

2. A T-square. The head and blade of this tool are usually fastened together at right angles with screws. The angle between the two parts is liable to variation, so its accuracy should be tested occasionally. The working edge of the blade should be bevelled, so as not to throw a shadow on the work. The T-square should always be held firmly against the left-hand side of the drawing board when in use. Any number of horizontal, parallel lines can be drawn thus. Lines at right angles to these can be drawn either by the aid of a set square, which is held firmly against the T-square, itself held against the side of the drawing board; or the T-square itself may be gently slid down the board while the fingers rest upon it and hold the pencil which rules the line. With a little practice lines can be ruled in this way quite as accurately as by the aid of the set square. The T-square should not be turned so as to work from another edge of the drawing board.

3. Two set squares. These are triangular pieces of wood, vulcanite or xylonite. Those having the angles of 60° and 45° are most generally useful. By sliding these tools along the T-square to other positions any number of perpendicular

or diagonal lines may be drawn. For sets of lines required at other angles,—place one of the squares on the paper so that its side points in the required direction; then put the T-square against it. Hold the T-square down and slide the other along it to the positions required for ruling the lines. If, however, much work has to be done at such an angle the paper may be slewed round on the board and pinned in a fresh position, so that the lines may be ruled by the aid of the T-square alone.

4. A set of mathematical instruments.

5. A protractor, for setting out angles.

6. Drawing pins. These should be driven in not quite at right angles to the board, so that some part of the heads touch the paper. They hold it better so.

7. Paper, pencils and charcoal. The latter is very useful for roughing in large work.

To transfer a drawing to metal. Put a sheet of carbon paper between the drawing and the metal and go over the outlines with a pointed tool. A knitting needle set in a handle, as the lead is set in a pencil, makes a useful tracing needle. Its point should be rubbed smooth. Another way is to use a mixture of virgin wax and whiting. Warm the metal and smear a very thin layer of the composition over it. Make a tracing of the drawing and turn it face downwards on to the white film left on the metal. Lay a piece of notepaper above and rub hard all over with the handle of a knife.

To draw on metal, first roughen the surface with fine emery paper or pumice-stone and water, taking circular strokes. Pencil lines made in any direction will show on this surface. Erasions can be made with fine emery used as before. A pen and ink may be used, and faulty ink lines trued up with a knife point.

The tools required in setting out work on metal are: A rule, preferably of steel. An accurate straight-edge, also of steel. A square;—this is made of two pieces of steel firmly fixed at right angles to each other. A pair of dividers

or compasses with quadrant. A marking tool made from a length of $\frac{1}{8}$ inch steel wire, ground to a sharp point.

It is a good rule to take all measurements and angles from one central or base line. In careful work, measurements should be transferred from the rule to the work by means of the dividers. In doing so it is well to avoid the last inch on the rule. A measurement of an inch, say, taken from the extremity of the rule is likely to differ a little from one taken at another part. Not necessarily because the rule has become worn and rounded at the end, but because one point of the dividers rests on the end of the rule—somewhere, rather than in an accurately placed cut on the surface.

In marking off successive measurements always add the length of the new section to the total of those which have gone before, and measure from the base to that total length. Greater accuracy is attained in this way than by that in which each successive measurement is carried on from the mark made for the last.

To find the centre of a straight line with the compasses, Figs. 303, 304. Open them to a span of about half the length of the line. Place one leg at A and make a mark C on or across the line. Lift the compasses and place one leg at B. Make another mark D on the line. The centre is exactly half-way between C and D. It may be guessed, or the space of the compasses adjusted until marks made from either end of the line, as above described, are found to agree. It does not matter if the dividers are set to too great or to too small a span in the first instance. The method to be followed is the same in either case.

The centre of any regular curve may be found in the same way, Fig. 305.

To divide a given straight line into any number of equal parts, Fig. 306. If you cannot do so by measurement with the rule, proceed as follows. From one end of the line E F, draw another line, E G, of any length and at any angle. From E along the line E G, set off the required number of equal

parts, say nine,—taking any convenient unit—inches on a foot rule,—for example. Join 9 and F. Then draw lines parallel to 9 F through each of the divisions, 8, 7, 6, etc., cutting the line E F. The line E F is now divided as required.

To find the centre of any square, Fig. 307. Draw diagonals H K and I J. They will cross in the centre of the square.

To find the centre of any circle, Figs. 308, 309. From any point in its circumference L, with a distance equal to about half the diameter of the circle for radius, describe a small arc, M. With the same radius from two other widely separated points in the circumference describe small arcs N and O. The centre of the circle lies between the arcs M, N and O and may be guessed. Or, adjust the dividers until arcs struck from any point in the circumference all pass through one point. This will be the centre of the circle. It does not matter if the dividers are set to too great or to too small a span at first.

To divide a circle into three or six parts, Fig. 310. Find the radius of the circle. This is the distance from the centre to the edge. From any point, P, in the circumference strike an arc of the same radius, cutting the circle in two places, Q and R. Either with Q as centre and Q R as radius describe an arc, cutting the circle in S; or draw a diameter passing through P and the centre to S. The circle is now divided into three equal parts in Q, R and S. To divide it into six, draw lines from Q and R through the centre, cutting the circle in T and V. Or, with P Q as radius and S as centre describe an arc, cutting the circle in T and V. Or, step the distance P Q round the circumference.

To divide a circle into any number of equal parts, Fig. 311. Draw a diameter A B, to the circle. With A as centre and A B as radius describe an arc. With B as centre and the same radius describe another arc, cutting the first in C. Divide A B into as many parts, say five, as you wish the circle divided into. Draw a line from C through the second division in all cases, whatever the number of parts may be,

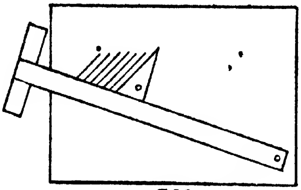
cutting the circle in D. Step the distance A D round the circle E F G. If A D, D E, E F, F G and G A are joined, a regular pentagon has been described in the circle. In the same way any regular polygon may be constructed. The pentagon has five sides. The hexagon six. The heptagon seven. The octagon eight. The nonagon nine. The decagon ten. The undecagon eleven. The duodecagon twelve.

To draw the given geometrical figures in the circles, Figs. 312, 313. Divide each circle into twice as many parts as there are foils. Let H be the centre of the circle. Find by trial the largest circle which can be inscribed in the space, H I J. Set out the distance from H to its centre on alternate radii and describe the other circles.

To work this problem geometrically, Fig. 313. After dividing the circle into twelve parts, draw K L at right angles to H I, and complete the triangle H K L. Bisect the angle K L H. You do this by taking L as centre and striking the arc N M at any distance. From N and M with any radius strike two other arcs crossing each other in O. Join O L, cutting H I in P. With P as centre and P I as radius inscribe a circle. It will fit exactly into the triangle H K L. With H as centre and H P as radius mark the centres of the other circles and complete the figure.

Problems similar to those given above are often met with in setting out the bases of cups, chalices, bowls, etc. They may be dealt with in yet another way—by the use of the protractor. If you remember that the circumference of a circle is divided into 360 degrees, you have a very small sum to do to find out how many degrees must be allowed for each part of, say a nine, ten, twelve or fifteen sided figure. You have then but to set out with the protractor the correct number of degrees for each part. For other and more difficult problems Morris's *Geometrical drawing for Art Students* is probably the best book to turn to.

To draw an ellipse, the length and breadth being given. Let A B and C D be the major and minor axes (the length and breadth). They are drawn in Fig. 314 crossing each other



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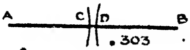

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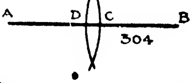

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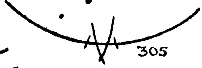

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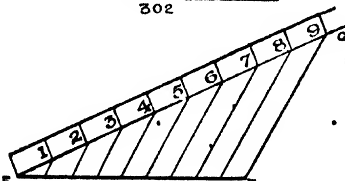

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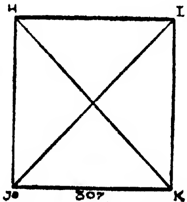

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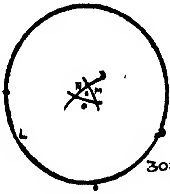

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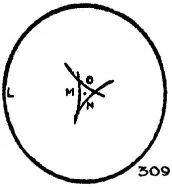

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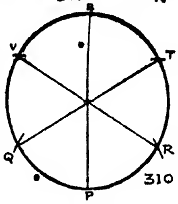

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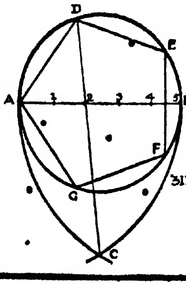

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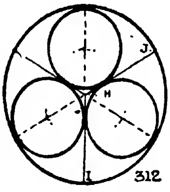

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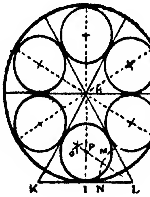

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at right angles. O is the centre both of A B and C D. With radius A O, and centre C describe an arc cutting A B in E and F. These two points are called the foci. Take three pins and stick them firmly in at the points C, E and F. Tie a piece of string round these three pins running from C to E, E to F, and back to C again. Remove pin at C and replace it with a pencil. Move the point of the pencil round, keeping the string tightly stretched. The curve traced by the pencil point will be an ellipse. G and H show the position of the pencil at three different times on its journey. The dotted lines proceeding from G and H to E and F show the position of parts of the string at those times.

Second method, Fig. 315. Set up the axes A B and C D as before. Take a piece of paper, or a long, flat ruler and make E F equal to A O and E G equal to C O. Place it so that G may be on the major (longer) axis and F on the minor (shorter) axis. Then E will be a point on the curve. By shifting the paper, and always keeping G on the major and F on the minor axis any number of points on the curve may be obtained. Draw the curve through these points.

In constructing narrow, deep vessels or those figures whose shape approaches that of a truncated cone, a considerable saving in time may be effected if a seam up the side be permitted, for in raising a deep shape without a join a good deal of time is required. Almost any vessel of the types shown in Figs. 316 to 318 may be constructed by cutting a suitably shaped piece to form its sides, and another flat piece for the bottom. But the exact shape shown in the figures could not be obtained from any flat piece of metal. The nearest one can approach to it is shown by the dotted lines inside each figure. They represent part of a cone—a tapering tube. If a piece of metal were cut to such a shape it could be altered into the form required by snarling and shaping. But remember that it is easier to expand parts of a shape to the correct size than to reduce them. So as a rule, draw the dotted lines just within the narrowest

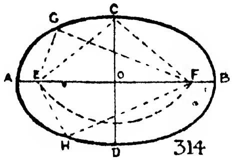
parts of the outline of the vessel. Experience only can guide you to choose the best position to place them. First draw the elevation of the vessel. Then, if its sides are not straight, mark in the dotted lines as indicated. Let A B C D, Fig. 319, be the elevation of the shape required. It would do, upside-down, for a bowl of the shape shown in 317. Produce the sides B A, C D till they meet in E. With E as centre and E A as radius describe an arc. With E as centre and E B as radius, another arc. Along the larger arc mark off F and G, making B F and C G each equal to B C. Beyond G, mark off H, making G H equal to one seventh of B C or of C G. This distance can be easily guessed. The total distance F H is, therefore, $3\frac{1}{7}$ times B C, see page 300. From F and H draw straight lines towards E, cutting the smaller arc in I and J. Then I F H J is the shape required. A piece of metal cut to that shape will curl up to form the sides of the vessel A B C D. The join up the side must be soldered and the metal snarled and hammered to the curved shape required.

In setting out ornament on the four sides of an oblong box, usually made from one long strip of metal, do not forget that the long and short sides come alternately. Thus: long, short, long, short.

The stems of candlesticks and other objects are often made with a spiral twist or flute, Fig. 323. This twisting or fluting can be worked upon the piece of sheet metal which is to form the stem before it is bent round into cylindrical form and soldered. Suppose that the twisted stem is to be 6 inches high by 1 inch in diameter. Take a piece of sheet metal measuring 6 inches by $3\frac{1}{7}$ inches, Fig. 322. (The drawing has been made too wide in proportion, by mistake.) On the back of the metal you have now to set out the lines of the ridges which form the twist. They will afterwards be driven up by repoussé work. Let us suppose that the ridges are to cross the stem as shown in Fig. 323. Divide the two long sides of the metal into nine equal parts. Draw a straight line from the top right-hand corner to the third

Proper names or dates should never be spaced so as to come partly on one and partly on a second line, if it can be possibly avoided, nor should any unusual division of a word be made. The number of letters which can go into certain lines of the inscription may be thus affected, and any variation must be reckoned with in finally deciding on the size of letter to be used. In the chapter on Repoussé work, page 131, there are given some further hints as to the spacing of lettering for execution by that process.

In setting out small work—an engraved pattern or inscription, for example—some difficulty may be met with in firmly holding the work in such a manner that a set square can be used on it. It is a good plan to make a rectangular ring of iron or brass, Fig. 321, the top and edges of which are quite true and square. Fix this on the pitch bowl with its upper part projecting a little above the surface. Work can now be fastened down on the pitch within the rectangle in the usual way, and the square held against the ring while lines are being ruled. It is, of course, necessary to keep the working edges of the ring quite free from pitch.



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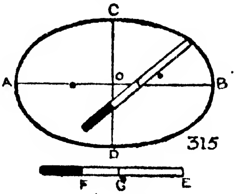

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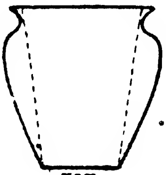
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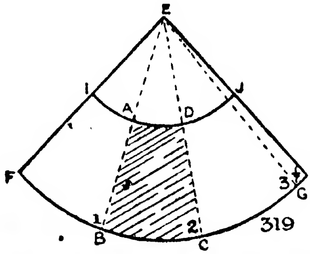

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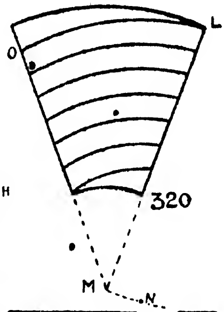

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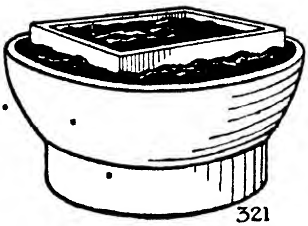
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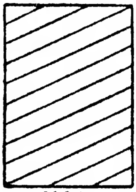
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CHAPTER XXIX

POLISHING, COLOURING AND LACQUERING

Polishing—Burnishing—Matt surface—The colouring of gold—Silver—Copper—Brass—Japanese metal colouring—Lacquering.

THERE is a wide choice open to you as to the manner in which a piece of work may be finished. It may be plated, coloured, oxidised, left with a dull (matt) surface or polished brightly. Let us take the polishing of a plain silver box as an example. After the final soldering the work is boiled out in pickle to remove the borax. All superfluous solder and other unevennesses are now removed with a file, and the work is gone over with a scraper. Particular attention is given to scratches. To remove a scratch. Scrape in the direction of its length, or diagonally, until the metal round about is scraped down to the level of the bottom of the hollow. Do not scrape across and into a scratch. Work in this direction will only deepen and widen the groove. The box may now be gone over with water-of-Ayr stone, pumice and water, or glass paper. The water-of-Ayr stone is a grey slaty stone. When wetted it should look light in colour with dark spots,—not even coloured. It is always used wet. The pumice may be in lump form or in powder. In the latter case it is applied with a flat stick or brush. Glass paper is used rather than emery, for if any emery gets into the lemel it is difficult to remove, while the glass comes away with the flux when the lemel is melted.

Curved rather than straight strokes are the rule in polishing: the work goes truer so. The various materials for polishing are used in the order of their fineness, the finest ones coming last. Care must be taken to remove every

particle of the coarser polishing materials before the finer kinds are applied. The sticks or mops used for each material are therefore kept in separate boxes or tins.

After one of the three materials mentioned above, a softer cutting material is used. This is blue stone; it is followed by either tripoli or crocus. The whole work is gone over each time, to get it to an equal smoothness. After this, jewellers' rouge is applied. It is mixed with water and just a little grease. The latter keeps the rouge from working into the surface and producing a reddish film which is difficult to get rid of. This discolouration is known as "foxing." A final polish is given with the hand alone. The work is then washed in warm water and dried in hot sawdust.

When using the polishing lathe take oil and crocus or tripoli on a brush, after the blue stone. Then with the same polishing material use a swansdown mop, centred truly. This will remove the brushmarks. Finish with rouge on another swansdown mop.

Copper or brass work is filed or scraped smooth. It is then gone over with coarse emery cloth, No. 2, and afterwards with fine, F.F. Or the work may be done on the polishing lathe with suitable bobs and mops.

The colour of silver when it has undergone the treatment indicated above will be very much that of an ordinary mirror, and its surface will be quite smooth,—all hammer marks, scratches and other traces of its manufacture having been removed. Now this high ("black") polish is only possible if the whole of the original surface of the silver has been removed in the process of polishing. For when silver "goes through the fire" in annealing or soldering, and is afterwards boiled out in pickle (see Chapter III), the colour of its surface is changed. It becomes rather greyer. This is owing to the burning out, "oxidisation," of the copper alloy near the surface. The copper oxides are dissolved during the pickling, and leave a thin film of pure silver at the surface. But this change of colour,

technically known as "fire," extends to an extremely minute depth; and is easily removed by scraping or grinding. Now it was found, long ago, that if you wished to obtain a high ("black") polish on silver, any parts of the work which had been scraped or filed after it had been made red hot for the last time, and boiled out, looked a different colour from the others. The scraped parts would have a yellowish tinge. So the custom of grinding or scraping the whole surface arose. Many people feel, however, that the "black" polish is obtained at too great a cost, for in the grinding and scraping necessary for its production all those touches which give a human interest to the work tend to disappear, and the work becomes machine-like—"icily perfect."

Work can be made quite bright by means of the burnisher alone. This tool is made in a number of different shapes, two of which are shown in Figs. 44, 45. The point is of steel, hæmatite (iron) or agate, and the handle about 9 inches long. In making a burnisher use the best tool steel. Shape it and get it as much polished as possible when soft. Then harden, and temper to a pale straw colour, see Chapter XXX. Polish it again with crocus powder. Finish with Sheffield lime on a buff. Keep the burnisher in order by giving it an occasional rub on a buff with putty powder and rouge. In using the burnisher, hold the blade towards you—at the little finger side of the hand. Lubricate the work with soft soap and water, mixed rather thin and cloudy; or with saliva instead. Turn the work about, alter the direction of the strokes till the surface is burnished quite smoothly. Then go over it with cotton wool on which is a drop of oil and rouge,—finally with clean cotton wool and dry rouge. Wash in warm water with soap, and dry out in hot boxwood sawdust.

A prong from a tortoise-shell comb is very useful for getting the polishing materials into narrow spaces,—the tortoise-shell being of just the right hardness to hold them efficiently. Quills or sticks of boxwood are also used for

this purpose. To polish small openings—pierced right through the work, a jeweller has a bundle of threads fastened under one of the arms of the bench. One or more of these is put through the hole and the work slid up and down the thread till the polishing material—crocus and oil, with which it is coated, has done its work. On other threads is rouge for the final brightening.

When all the scratches have been removed and the surface of the work is quite true, say, after the water-of-Ayr stoning, or better, after the tripoli, a dull ("matt" or "frosted,") surface can be obtained on silverwork as follows. Make the work red hot—to oxidise the copper alloy at the surface,—then boil the work in dilute sulphuric acid. This solution removes the copper oxides from the surface and leaves a thin film of pure silver all over. The colour of the silver is now a dead white. A rougher unpolished surface can be obtained by sand-blasting. In this process fine sand is blown by compressed air against the work. It makes quite a dull surface, like that on ground glass. Yet another very fine dull surface is obtained by the use of a wire brush on the lathe. In all these methods of finishing work the scratches must be removed first, otherwise they will show.

The colouring of different metals will now be discussed—gold first. The colour of alloyed gold, and of the solder employed in goldwork, differs somewhat from the fine yellow colour of pure gold. The surface of all alloyed goldwork is therefore treated in such a way, after it has been polished, that no alloy is left at the surface. The work then, after colouring, looks as though it were composed of pure, unalloyed gold. There are three principal methods of tinting gold—by dry and wet colouring, and by dipping or flushing. In the last-named process, the work after polishing, is dipped for a few seconds into a gilding solution and the electric current passed through it. A thin film of pure gold is thus deposited or flushed all over the work. This process has almost entirely superseded that of dry

colouring. The latter process cannot safely be applied to gold of a lower standard than 18 carat.

Wet colouring is the process employed for alloys of 14 carat or better quality. By this method the alloy near the surface of the work is dissolved out, leaving pure gold only. For poorer qualities of gold it can hardly be employed, for in alloys of less than 12 carat more than half the mass of the work is composed of alloy. The solution would therefore attack a large proportion of the surface of the work and leave it rather rough. For the better alloys of gold the roughening of the surface due to the dissolution of the alloy there is very slight, and may be ignored. The solution employed is—

Potassium nitrate = KNO_3 (known also as saltpetre or nitrate of potash), ...	8 oz.
Sodium chloride = NaCl (common salt) . .	4 ,,
Alum	4 ,,

Mix the ingredients in an ordinary melting-pot. The latter should stand on an iron plate on a gas ring. The heat should be applied very slowly at first, but the solution should be used when boiling. Sufficient hot water is to be added to the mixture to make a thick paste, which must be well stirred with a stick. The work should be annealed and boiled out in nitric acid pickle to remove any grease or other foreign matter. It is then suspended on a silver wire or on a horsehair and dipped into the hot colouring solution. It may stay there for five minutes at first. Lift it out and dip it into boiling water. Add one or two teaspoonfuls of hot water to the colouring solution and replace the work for four minutes. Remove it again and well rinse in boiling water. Its colour should be improving. Add two more teaspoonfuls of hot water to the solution and dip the work again for three minutes. You go on weakening the solution and shortening the time of immersion until the colour of fine gold has been attained. The work should not remain in the solution for more than twenty minutes altogether.

Some colourers add $\frac{1}{2}$ to 1 oz. hydrochloric acid (spirits of salt or muriatic acid) to the ingredients mentioned above after they have been well mixed. Others add the acid after the work has been dipped once. Others, again, add it only when the solution is getting weak. If hydrochloric acid is used at all the time the work spends in the solution should not exceed fifteen minutes altogether, for the action of the acid is to hasten the dissolution of the alloy If the work remains in the solution too long or the gold is too poor in quality its surface will be eaten away. It is well to avoid the fumes given off from the hot solution, for they are poisonous. After colouring, the work should be scratch-brushed to make it quite bright; or you may frost it with the scratch-brush. In this process the ends of the wires of which the brush is made are allowed to spring on to the work from a stick held against them for that purpose.

We now come to the colouring, or oxidising, of silver, copper and brass. To do this successfully it is absolutely essential that the metal to be coloured shall be perfectly clean. Any dirt, grease or oxides on its surface will prevent the solutions from acting evenly. When the work has been cleaned it should not be touched by the hand, or even exposed to the air for longer than can be helped. All borax should have been removed and all filing and polishing of the surface completed before the colouring is undertaken. A copper wire may be fastened to the article for suspension, to save it from contact with the hands. The work is now boiled in a solution of potash or soda to get rid of any grease. One pound of potash to one gallon of water is a good proportion. The work is then well rinsed in clean water before putting it into the colouring solution. Small work, a brooch or necklace which has been in use, for example, may be cleaned with benzine before colouring. Larger work may be cleaned with fine sand and water, applied with a nailbrush. Bath brick or pumice powder may be used instead. This will not roughen the surface of the work so much.

Care must be taken not to allow any of the colouring

solutions to make their way into the settings of translucent stones, for the solution would dull the foil or other backing.

It is a good plan to remove the work from the solution as soon as it has begun to take effect, and to give it a good scratch-brushing. Then after a rinse in clean water it may be replaced in the solution. A more even colouring is generally attained in this way than if the scratch-brushing is omitted.

The action of the solutions given below may be stopped at once by removing the work and rinsing it well in clean water. The work will come a little lighter in colour during the subsequent brightening up, so the colouring should be allowed to proceed till the shade produced is rather darker than that finally required.

The Colouring of Silver.

Blue. This colour may be obtained by exposing the work to the fumes of sulphur (S) heated in a closed box.

Grey. Platinum chloride ($PtCl_4$) in alcohol, painted on with a brush. When dry it may be lightened in colour by scratch-brushing or by brushing with pumice powder.

Blue-black. One of the following solutions used hot :—

Potassium sulphide (K_2S)	10 grains
Water	10 ounces

or—

Barium sulphide (BaS)	10 grains
Water	5 ounces

Greyish-brown. Ammonium sulphide ($(NH_4)_2S$) painted on with a brush.

Gold Colour. A cold solution of

Barium sulphide	10 grains
Water	10 ounces

or, a hot solution of

Ammonium sulphide	10 grains
Water	5 ounces

If the work is allowed to remain long in either of these solutions its colour will gradually change to crimson and brown.

Brown. If the work is dipped in a hot solution of

Barium sulphide	10 grains
Water	10 ounces

or—

Ammonium sulphide	10 grains
Water	5 ounces

its colour will change rapidly from gold, through various shades of crimson, to brown. If it remains after this colour has been attained it will turn rather greyer.

THE COLOURING OF COPPER.

Most beautiful golden-brown colours may be produced on copper by heat. The work should be suspended a foot above an ordinary gas ring and moved about so that it is evenly heated. After the golden colours the work turns purple and finally grey. If the heating is continued it will turn black. None of the colours just described are permanent, though they may last for some months.

Antique Bronze Patina. Bury the copper articles in a box of mould which has been previously well moistened with strong vinegar. Or, dip the work in

Copper nitrate crystals ($Cu(NO_3)_2$)	10 grains
Ammonium chloride (NH_4Cl)	10 ,,
Calcium chloride ($CaCl_2$)	10 ,,
Water	½ ounce.

Dark Brown. A cold solution of dilute ammonium sulphide, or a similar solution of potassium sulphide.

Black. A strong hot solution of barium sulphide. If this is used cold the action is much slower. The colour changes from light to dark brown before turning black.

THE COLOURING OF BRASS.

Black. A hot solution of

Copper sulphate ($CuSO_4 \cdot 5H_2O$) 2 ounces
Water just sufficient to dissolve the copper sulphate
Ammonia (NH_4OH) just sufficient to redissolve the precipitate which first forms,

or—

Arsenic	50 parts
Hydrochloric acid	250 ,,

then add—

Chloride of antimony	35 ,,
Finely pulverised hammer scale	35 ,,

This solution is used cold. Rinse the work before and after immersion in a warm soda solution.

Brown. A strong hot solution of barium sulphide.

The following notes were given to the author by the late Sir W. C. Roberts-Austen, Master of the Royal Mint, London :—

"The method adopted at the Imperial Mint, Asaka, Japan, for colouring copper medals—

Copper sulphate	2·25 grammes
Rokusho (a kind of verdigris)	7·5 ,,
Distilled water	1·8 litres.

The solution, without filtration, is placed in a copper pan and briskly boiled. The medal is first boiled in a weak lye made by lixiviating wood ashes. It is next carefully polished with charcoal powder, and then dipped in plum vinegar containing a little common salt. After removal from the vinegar solution it is passed through a weak alkaline lye, and then placed in a tub of water and well washed. The medal is now placed in the boiling colouring solution and kept immersed for several minutes, in a wire cage. Once or twice it is lifted out quickly and immediately

placed in cold water to ascertain the shade of colour which has been produced. If too light it is replaced in the boiling solution. If it is the proper colour it is washed thoroughly with cold water and wiped dry with a cotton cloth. When the solution has been in use for some hours a pinch of verdigris or copper sulphate should be added if its action appears to have been weakened. Otherwise, after prolonged boiling, loss by evaporation should be remedied by the addition of pure water.

"In preparing the medals for the colouring solution they should not be allowed to remain for very long in the water before boiling them, or the colouring will be irregular.

"JAPANESE PICKLING SOLUTIONS.

	I	II	III	IV
Verdigris	175 gr.	18 gr.	90 gr.	
Copper sulphate ($CuSO_4$)	116½ ,,	87½ ,,	214 ,,	333 gr.
Sulphur		48 ,,		
Nitre (KNO_3)		18 ,,		
Salt (NaCl)		15 ,,		333 ,,
Vinegar			¾ oz.	
Water	70 oz.	35 oz.	70 oz.	35 oz."

These four formulæ differ somewhat from those already published by Roberts-Austen, but they represent the solutions which he had found most successful in actual practice; see Japanese alloys, page 177 of this book.

A valuable work on *Metal Colouring* has been written by Mr. A. H. Hiorns of the Municipal Technical School, Birmingham. To this book the reader is referred for any further information on the subject.

To preserve the colours produced by chemical solutions on copper and brass the work is sometimes lacquered. This process consists in coating it with a thin layer of some transparent lacquer or varnish. The work should be done with judgment or the metal may lose its true metallic sheen and appear as though painted. The work is either painted with or dipped into the liquid lacquer. It is then put into an oven and thoroughly baked. A lacquer, however, which

can be used cold is known as Zapon. It is a preparation of celluloid in acetate of amyl. The work afte being painted with this liquid should be stood on a warm plate till the semi-opaque streaks, which have appeared during the application of the lacquer, have disappeared, and the lacquer has become quite transparent again everywhere.

CHAPTER XXX

THE MAKING AND SHARPENING OF TOOLS

Carbon steels—Alloy steels—Forging—Hardening—Tempering—Tempering in metal bath—Grinding—Sharpening.

ALTHOUGH you may buy ready made, or have made to your order, tools of any shape, yet some experience in the making of the simpler kinds is very desirable. A repoussé tool of some special shape is required, a small chisel, a mandrel for winding wire upon. Days or weeks might pass before the right tool could be obtained. Yet it could be made in a few minutes, in half an hour. Let us try. But first a word or two about the material of which it is to be made. Knives, chisels, files, drills, cutting tools generally, and many other types of tool are made from steel. This material is iron, made stronger and tougher by the addition of small percentages of carbon, tungsten, nickel, chromium, vanadium, etc. The actual proportions used to produce what is known as tool steel are often trade secrets. But tool steels may be roughly divided into two great groups: "Carbon steels," and what are known as "alloy or high speed steels." The former contain from $1\frac{1}{2}$ to $\frac{3}{4}$ per cent. of carbon. They were in general use up to 1894, and are still very widely used for general purposes. Carbon steels, however, begin to lose their hardness at a temperature of 260° C., so, though quite suited for all the ordinary tools used by metalworkers, they cannot be used for high speed work on lathes and milling machines. There is no convenient way known in which they may be kept cool enough to retain their temper. Alloy or high speed steels are those in which the iron is mixed with a small percentage of tungsten, or one or more of the other metals mentioned above. These steels will keep

their hardness even when red hot, for they may become heated up to about 650°C., a dull red heat, without their cutting capacity being seriously impaired. However, carbon steels are those which one is most likely to meet with. They are made in different brands for various kinds of tools. Those containing much carbon will stand less heating than those with less. But none should be heated more often than absolutely necessary, for with repeated heatings the carbon is burnt out and the quality of the steel impaired.

Tools made from steel are hardened and tempered as described below. Tools made from iron cannot be hardened to the same degree, though there is a process, known as case-hardening, by which the surface of an iron tool can be turned into steel, so that it may be afterwards hardened. But this process takes a good deal of time, and is unsuited for the work we are discussing. Brass also is too soft for cutting tools. It is sometimes used for repoussé tools, but those made from this material should be avoided. They are liable to get bent or otherwise damaged. Let us therefore take tool steel for the work we have in hand—a small chisel, shall we say. Tool steel may be bought in rods, round, square, hexagonal or octagonal, of almost any size. Take a $\frac{5}{16}$ inch octagonal rod and cut off $3\frac{1}{2}$ inches. To file it to shape would take too long and would wear out the file unnecessarily. To hammer it to shape when cold would be almost impossible, for it is so hard that it would probably crack in the process. It must be forged when hot. Any good fire will supply sufficient heat, but the work can be done in a furnace or with a blowpipe. Take a pair of strong pliers or tongs with which to hold the tool you are making, and put the end of the piece of steel rod in a clear part of the fire. Now tool steel can be forged when red hot, but it should not be brought to a pale yellow or white heat, such as the brightest part of a good fire, more than a few times. Nor must hammering proceed when it has cooled down to a dull red heat. In the former case it will become technic-

ally "burnt," and in the latter it is liable to be cracked. When the steel is at the right temperature hold it with the tongs and hammer it to shape on an anvil or some heavy stake, using any suitable hammer. If it gets cool before you have finished, heat it again. It may be finished with a file where necessary. Then reheat it to a cherry red and allow it to cool down quite slowly before hardening and tempering.

To harden a steel tool. Prepare a vessel or bath of water in which to cool the tool. It should be large enough for this to be done without any appreciable heating of the water. Add some salt to the latter. Salt water or brine gives greater hardness than pure water. The temperature of the bath should not be below 60° F. (16° C.). Heat the tool to a bright red colour. Stir the water so that it is going fast round and round in the pail or whatever vessel you are using. Then plunge the tool straight down into the swirl, holding it in the tongs and moving it about until cold,—the object being to get the tool cooled as quickly and evenly as possible. Moving water does this quicker than still water. Tools are sometimes quenched in oil, mercury or other liquids: small ones by sticking the point into a tallow candle. The use of oil or tallow for this purpose makes for toughness in the tool rather than for great hardness. Tools made from alloy steel are usually hardened in oil, though for some brands a blast of cold air is used instead. To return to our work. The tool is now hardened, but it is extremely brittle. If used in its present condition its edge would break almost at once. Before it can be safely used it must be tempered.

To temper. First clean up one side of the tool by grinding it on a stone or on emery paper. It is too hard to use a file upon,—you would only spoil the file. The tool should be made quite bright and clean. Next apply heat to one end or the middle of the tool, but not to the point. This may be done with a blowpipe, or by laying the shank of the tool on a piece of red-hot iron, but

in no case must the point be heated directly. It will get gradually heated as the warmth creeps up the tool. As the tool becomes hot the colour of the polished side changes. Bands of different colours appear close to where the heat is applied and creep down the tool towards the point. First pale yellow, then straw colour, then brown and finally blue like that on a clock spring. These colours indicate different degrees of hardness. Steel, tempered pale yellow, is very hard but very brittle. It is useful for razors and fine cutting tools, but it is too brittle to stand any hammering. Chisels are tempered to a brownish yellow or dark straw colour at the point, the shank of the tool being not quite so hard. For, the tempering being done as above described, the shank of the tool gets hotter, and softer, in the process than the point does. Saws are tempered blue, as they must be flexible and not brittle. When the colour at the point of the chisel indicates that the temper has been "let down" sufficiently, any further softening is stopped by putting the tool in cold water again. The chisel has now been hardened and tempered. It must yet be ground and sharpened for use.

To temper a small drill. With the pliers hold a piece of sheet copper, measuring about 3 inches by 1, over a Bunsen burner or small gas jet. With another pair of pliers hold the drill by the shank over the copper. Let part of the shank of the drill touch the edge of the copper. The copper will protect the drill from direct contact with the flame, yet sufficient heat to temper it properly will reach the drill through its place of contact with the copper. Proceed as described above.

To temper a spring. Cover the spring with two layers of iron binding wire, about 26 Standard Wire Gauge, coiled quite closely. Dip it into sweet oil, olive oil, linseed oil—whichever you have by you. Hold it over a flame until it catches alight. Let it burn itself out. At once uncoil the wire, and the spring will be found to be properly tempered. It is not necessary in this case to dip the work in water to stay

the tempering. If two or three strands of the wire are coiled on the spring at once the work is done quicker.

The colours to which steel tools are tempered for various purposes are given below with temperatures—

	Cent.	Fahr.	
Light straw colour	221°	430°	Razors.
Dark straw . .	243	470	For wood, ivory and vulcanite tools.
Brown yellow. .	260	500	For gravers and tools for metal-cutting.
Bright blue . .	288	550	For springs and saws.

A method by which the temperature—and hardness—of the steel may be accurately regulated is that by which the tempering is done in a bath of molten metal. Different alloys of lead and tin can be made, the melting points of which correspond with the various degrees of temper required in the steel.

Composition of Bath.		Melting-point.		Colour of Steel at Temperature given.
Lead.	Tin.	Cent.	Fahr.	
14	8	215°	420°	Very faint yellow.
15	8	221	430	Faint yellow.
16	8	227	440	Light straw.
17	8	232	450	Straw.
18·5	8	238	460	Full straw.
20	8	243	470	Dark straw.
24	8	249	480	Old gold.
28	8	254	490	Brown.
38·8	8	266	510	Brown with purple spots.
60·8	8	277	530	Purple.
96	8	288	550	Deep purple.
200	8	293	560	Blue.
Boiling linseed oil.		316	600	Dark blue.
Melted lead.		322	610	Grey blue.
Melted lead.		332	630	Greenish-blue.

To grind a chisel. The angle between the two faces at the cutting edge of a chisel varies with the material which is to be cut. The harder the material, the greater the angle

between the two faces. Thus for paring soft wood an angle of 15° or less may be used, but it would not be safe to use the mallet with so slight an edge. Much depends upon the thickness of the tool a little way behind the edge. The edge of a good hollow-ground razor in working order has an angle of about 16°, for in setting a razor the thickness of the back regulates the angle at which the edge is ground. An angle of about 25° is safe to use with a mallet in hard wood, if the tool is tempered rightly. For metal the angle at which the chisel point is ground must be blunter still. For work on thick metal the thickness of the point a little way from the edge is perhaps as important as the actual angle of the cutting edge. For the blows given are fairly heavy, and they drive a narrow chisel deep, whatever the form of its edge may be.

Grinding is done on a grindstone or an emery or corundum wheel. So great is the amount of heat produced in this process, that unless the stone is kept wet, in the course of a few seconds the tool will get so hot that its temper will be spoilt. In that case it must be hardened and tempered afresh. Tools may be ground with the grindstone running either towards or from you. The stone "running towards you" means that when you are in the position for grinding a tool, that part of the grindstone between the top of the stone and your hands is travelling towards your hands. It is a little more difficult to hold a tool when the stone is running towards you, but the work is done quicker. Each of the two sides of the chisel which meet at the cutting edge, should be ground quite flat, or even slightly concave (following the curve of the grindstone), but never convex. The tool is held in the right hand, and its further end is pressed against the stone by the first two or three fingers of the left hand. The angle at which the tool meets the stone can be adjusted by raising or lowering the hands. It is usual to move the tool from side to side of the grindstone as the work proceeds. This is done to avoid wearing grooves in the stone. It sometimes happens, in grinding with the stone

running from you, that an edge of metal, as thin as a sheet of paper and quite flexible, is left at the extreme edge of the tool. This is known as the "wire edge" or "arris." It will generally break off in the course of sharpening and leave the tool quite keen. When the grinding has proceeded far enough the chisel may be sharpened on an oilstone.

Sharpening is but a continuation of the process of grinding. It is done on smoother stones,—slower in cutting. But a finer edge is produced than it would be possible to obtain with grindstone alone. Lay the oilstone on the bench with its end to the front edge of the bench. Hold the tool as before, and rub from end to end of the stone. The middle part of a stone generally has more wear than the edges, and so gets worn hollow. Try to avoid this. Proceed with the sharpening until the rough scratches left by the grinding have been smoothed out, and the tool has a true, dull-polished surface at the extremity. The wire edge may still be present, but it will be rubbed off later on the strop.

Stropping produces an extremely fine polished or burnished edge to a tool. The strop, like the oilstone and grindstone, acts by rubbing off some of the metal near the edge of the tool. The only difference is that it is less coarse than they. Use a mixture of tripoli, rouge and tallow on the strop. It is well to remember that in the case of any cutting tool whatsoever, whether it be a pocket-knife for peeling an apple, a drill, or a lathe for a 14-inch gun, the efficiency of the tool ultimately depends on the keenness and truth of the last hundredth, or twenty-fifth, or sixteenth of an inch, whichever you like, of that tool's cutting edge. All the rest of the tool is but handle, with various labour-saving devices, for applying that cutting edge to its work. It is well, therefore, to see to it that the cutting edge of your tool is correct in form and properly applied.

CHAPTER XXXI

DESIGN

In the national museums we have vast collections of work of all ages and countries. This work is valuable to us in many ways, but not least in showing how the old craftsman thought out the problems which were set him—problems in many cases new. We gain a useful experience if we try to put ourselves in the old worker's place, and think out the problem from his point of view. He generally had to work with less efficient tools than those available to us. He had no gas to solder with, for example. He often had to make his own files and solder. He had to melt his own silver or gold and cast it into an ingot of suitable shape for the work. He often carried the whole work through alone. For he was capable of doing the raising, the repoussé work and chasing, the fitting and the soldering, the enamelling or niello work and the gilding. All these things reacted on the design. For he had his say in that also, and we can see how his personal equation asserted itself in this. One craftsman was fond of trying twisted wire patterns, another of enamelling, another of niello or repoussé; and he makes you see that he is interested in it. The modern practice whereby the gold- or silver-smith confines himself to a single branch of the craft, does undoubtedly result in wonderful technical skilfulness, and in cheapness of production. But its influence is definitely against the production of work which "holds together" artistically. For that quality is hardly to be obtained when the work passes through so many hands, and each craftsman, perhaps naturally, endeavours to make his part of the work "tell" most. The subordination of some parts is essential in a work of art. So it comes

to this. The great bulk of the work turned out in future will continue to come from workshops carried on as at present—one job passing through many hands. For the majority of the people who buy do not worry about the artistic quality of the work at all. But there will always be a demand, and an increasing demand, for work executed throughout by one man—a man who can both design and carry the work through.

We in our day, like the old craftsman in his, must think out the problems in our own way. We know, far better than he, what has already been done. Our books and museums tell us that. But to copy an old work, or to collect details from this and that and to put them together as a new design is not enough. For we must remember that if the people who care for artistic work and good craftsmanship are to be interested in our work, it can only be if they can see in it that we were really interested in it ourselves. If we think the thing out for ourselves, if we suppress, strengthen or modify details of our design because we feel that it will be "pulled together" by our so doing, we are putting into it thoughts which will interest those who care for artistic work. If we have a care for fine craftsmanship, others also will appreciate our work. But to hold the balance between fine design and fine craftsmanship, so that the latter, though present, shall not take precedence over the former—that is the true aim; and we are happy when we strive for it. Eccentricity in design certainly catches the eye; but it is almost impossible to live with. Over-insistence on technique, craftsmanship which proclaims "How clever am I!" quite naturally elbows out artistic feeling. One idea must be the principal one; and if that happens to be technique, the other goes.

If we look at Nature she will give us many hints as to design. We must look not only at plant forms, but also at butterflies, beetles, lobsters and crabs. At bones also—the forms at the underside of a human skull, for example. We should model the forms to really understand how they

go. We should consider all the modelled or carved work that we meet with; and try to understand why the sculptor or carver turned this form so, and that in the other direction. The study of the work of a sculptor like Alfred Gilbert is a true education. The details of his Piccadilly fountain, for example, will well repay a thorough consideration. They have a wonderful flow of form and line.

The objects which we design may be broadly divided into two classes. (1) Objects intended primarily to look beautiful, their usefulness being but a secondary consideration, or no consideration at all. In this class come the mediæval nef and standing cup, and the modern table-centre. And (2) objects intended for use. These may be as beautiful as the others, but certain limitations must be observed in their design and construction. They are intended primarily for use, so nothing must be allowed to interfere with that. The lip of a cup which is to be used must be of such a form as to allow of it. The spout of a jug must be a practical one, and the handle of a form which would allow you to lift and empty the vessel. The base of a lampstand must be sufficiently wide and heavy to ensure the safety of the lamp. A door-knocker should be so designed that it would be possible to grasp the knocker—and that it should be heavy enough.

The first point, then, to remember in designing anything whatever is that the object made shall efficiently fulfil its purpose. If it is primarily intended for decorative purposes and its practicability as a usable object is of minor importance,—then you are free from the limitations of usefulness. Its principal purpose is that of looking beautiful. But if the object is primarily intended for use, no beautiful proportion, no amount of decoration will compensate for any omission in that respect. The prize cup, Fig. 324, is an example of a design which is a failure. For though a prize cup may be used a few times for drinking from, that is not its principal purpose. It is primarily intended as a thing to be looked at, as a pleasant souvenir of a successful effort. But this cup is not pleasant to look at,—it is so bad in pro-

portion. It is certainly a usable cup, but its more important purpose has been overlooked. Fig. 325 shows an unusable lip.

Having then settled the purpose which your design is intended to fulfil, the first things to consider are proportion and mass. Until these are settled it is of little use to go into details. You must consider the proportion between part and part. It is not well to divide a design horizontally or vertically into two or three apparently equal parts. One part should take precedence. It should be greater in height or width or bulk than the other part or parts. The fact that they are so subordinated to the principal mass very greatly assists in giving that feeling of unity which is so necessary to any work of art. It is true that the principal mass need not be very much greater than its subordinates, but in some way it must be more important—either in form or colour.

The feeling of unity just mentioned as being an essential feature in a work of art may be explained in the following manner. If a number of lines or other forms, Figs. 326, 327, are strewn about in an irregular manner the impression given is that of a number of objects. If, however, the lines or forms are arranged in some regular order—to make some pattern (as in Figs. 328, 329)—the mind is able to grasp them all at once as a unity—a star, a border. The forms need not be all alike for this purpose. What is necessary is just that there shall be some formal order in the grouping. An untidy room worries one not just because various articles are out of place, but rather because, in the artistic sense, there is no unity in it. Books are strewn about at various angles on tables and chairs, the tablecloth is awry, letters and papers are here, there and everywhere, the furniture is moved into awkward places, and so on. You have but to put the books, furniture and the other things into some formal order (not necessarily into their proper places), and the sense of untidiness will vanish. You have obtained order and unity once more. You will

find that this sense of unity is essential in a work of art. Your attention must not be distracted by lines, forms or colours which do not help towards its attainment.

It is difficult to say why this sense of unity gives so much satisfaction. Without doubt it is a lesser intellectual strain to think of the work as a unity than to remember a number of different parts. Just so it requires more effort to describe the various characteristics of some flower, the name of which is unknown to us, than to point to it. The concept of the work as a unity of definitely recognisable form is less difficult to us than an attempt to grip mentally a number of different facts about it—so we prefer the former.

A number of more or less naturalistic details put together will not make a design. The details must be bound together in some formal manner. You feel the need for some architectural feeling—principal and secondary masses; a feeling for symmetry; horizontal and vertical lines to give steadiness to the composition, and to afford a contrast to the more playful curved parts.

The details of the ornament should be kept to about the same scale throughout the work, no part looking as though it really belonged to a larger (or smaller) work. No feature in the ornament should be allowed to overpower all the others. Geometrical forms have an unpleasant habit of doing this sometimes. Thus, a diamond or oval shape in a panel may easily become too prominent; or a long line of simple curvature may show up more than you wish. To quiet curved lines you may cross them by others; or you may employ straight lines to contrast with and steady them.

A feeling for growth is most valuable. It helps you to trace long lines through the composition, tying up the various parts of the design by leading the eye on from one to the other, just as your eye may travel from the ground, up the roots of a tree, Fig. 330, up the stem, up the branches and right round the outline without any very sudden break. And in the leaf, Fig. 331, it is easy for the eye to travel in the direction of the dotted line, jumping across the notches

without a check. So in a design it is restful, it gives a feeling of satisfaction, a sense of unity, if your eye may travel from part to part of the work without any very sudden jerk. The working of this rule may be traced in objects of art of quite another kind. If you look at a picture by an artist who had a feeling for line—Raphael, or our own Burne-Jones—you will see how no part could be taken away from the composition without injuring it, for the lines which bind all the picture together, making a unity of it, would be broken. If you should be able to remove a portion of any design without injuring it, you may be sure that the design is not sufficiently thought out and bound together. The leaf, Fig. 332, may be compared with the other. It shows lines which do not "follow on" or "compose" well.

No part of the design should be entirely cut off from the remainder by a very strong line. The lines of composition should be so arranged that the eye is led past the dividing line, that the different parts overlap a little, as it were, tying themselves up with the lines on the other side of the division. In the illustration, Fig. 233, the tails of the mermaids are carried down below the base of the bowl to pick up the line of the stem. If they had finished against the cup all the upper part of the design would have been apparently cut off from the stem.

Constructional lines should always be acknowledged. Thus, ornament from the panels should not overflow any of the edges or corners of a box, ignoring the constructional value of these features. The ornament should either decorate the panels of the box, or the edges, or go in bands round it. The same pattern should not sprawl over parts of a side and an end, say, in an informal manner, leaving other parts plain.

Straight horizontal or vertical lines have a wonderfully steadying effect on a design. It does not seem to matter how playful and curved the other lines may be if you have a number of these steadying lines. They must be repeated with sufficient strength to pull the whole work together.

The instability and want of restfulness of much continental art and of works designed in the style of *l'art nouveau* are due very largely to the absence from the work of these strong horizontal and vertical lines. If a design looks fussy or flippant it is a fairly safe rule to try the effect of some of these steadying lines upon it.

It is an excellent plan to model a design to full size in clay, wax or plasticine. You can then see exactly how things will come, and you can try experiments. See if it will help to make any of the shadows deeper, or the mouldings stronger. See that the whole work does not look too flat or shadowless. See that the lines flow gracefully, that the ornament is right in scale, that each part has sufficient room. If you work thus you may make a work of art. Do not settle everything on paper first.

Let your ornament be appropriate. Fishes on a fire-screen look out of place—in the drawing-room at any rate.

Do not cover the whole work with ornament. Leave plenty of plain spaces to contrast with it. You may then make the ornament as rich as you please.

A moulding is a device by means of which a line of light and shadow may be drawn across the work, or an angle filled with interesting light and shade. Thus the angle A B C, Fig. 334, has to be dealt with. You may choose to fill it with the straight line, A C, and the effect in front will be that of a flat, grey shadow. This shadow will be made darker at the top and lighter below if you curve the surface in as in the dotted line. But you may wish to have a line of light instead of shade at the top. To obtain this you bulge the moulding out as in Fig. 335; and if you also like a little streak of light at the bottom you tilt the surface out again there. Or you may prefer to reverse the order and have the light at the bottom, as in Fig. 336. You may, if you will, break the mouldings up into many parts, large or small. The various members look better if they are varied in size and curvature. The light and shadows on curves which are sections of ellipses, Fig. 337, look much more graceful than

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those on curves whose sections are based on the circle, Fig. 338.

Perhaps it is hardly necessary to point out that you should never design anything without taking into account the amount of money available for the work. The cost must enter into your calculations as an essential factor in the majority of cases.

The importance of precious stones and enamels can hardly be over-estimated. Let us try to think what their purpose may be artistically. We will first take a glance at the materials we have to use,—their colours and textures. We deal with metals of various colours. White or grey—platinum, silver, steel, etc. Yellow—gold, brass, etc. Black—niello. Red—copper. Various browns and greys obtained by oxidisation. Textures vary from a dull matt to a highly polished surface. And surfaces are of any form, tilted to or from the light. We have also ivory, coral, pearls, opaque and translucent enamels and stones. Apart from expense and other considerations, these materials differ in artistic "quality" and "preciousness." A highly polished piece of metal looks more precious than a similar piece of metal with a matt surface. A coloured, brilliant stone, is more important than a dull-coloured or a dull-surfaced one; just as a piece of brick has less of this quality of preciousness than a polished flint. The hardness, brilliance and smooth surface of the latter set it above the former, making it more important artistically.

Now we are in a position to ask: What is the essential purpose of, the real reason for, the use of jewels as such—of enamels as such? They represent the most precious looking, the richest in colour, the brightest and clearest in texture of all the materials with which we have to deal,—something to which all other work and material may lead up. It is not because they are costly; it is not so much, at bottom, because they are rare; but because they form the culminating point in the scale which leads from the duller and poorer materials up to the richest and most precious looking things

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priests in bright raiment, brighter than the walls, one step higher in our scale. And you see there "the fair linen cloth,"—the one touch of white, with bright golden vessels on it. And high over the altar, the centre and culminating point of that which has spread the fame of this great cathedral far and wide throughout the world, is the great Pala d'Oro, the golden altar-back with its million's worth of gold and jewels. Everything leads up to it. And you feel the glow of colour in your eyes, the scent of incense in your nostrils, of music in your ears, and through it all ring the clear tones of little boys' voices. And that—that is St. Mark's. Its fame is not due to the mosaics or the marble, but to the artists who kept the whole work in tone, and let all the decoration lead up to the one central point of interest, and through that to the song of praise. There is hardly a discordant note. You would like to see mediæval dresses and armour worn there, for modern garb is dull in comparison. But the church is great enough to hold its own, and to teach to those who would learn, the great principles of colour and of unity.

St. Mark's at Venice stands almost alone among buildings in its triumphant carrying out of these two principles. If you turn to almost any other church—to some of the French cathedrals, for example—you find large masses of quite inharmonious colour thrown about anywhere and everywhere. Large pieces of white marble, with black marble for contract, which are sufficient to destroy any attempt at tone or colour. If colour is wanted, they must go. In the Roman Catholic Cathedral at Westminster you have a large new church which is to be decorated throughout with coloured marble and mosaic, yet the chancel and some of the side chapels are already ruined. For, by the introduction of jarring colours and masses of white and dark stone, any hope of attaining a colour harmony has been destroyed. Time alone can tone down some of the worst passages. You have but to enter the Chapel of the Blessed Sacrament in the same church to feel the contrast,

for this chapel has dainty and beautiful colour throughout, and the colour is kept in harmonious tones, though they are a little cold.

The little mortuary chapel at Compton, near Guildford in Surrey, erected and decorated by the late George Frederick Watts and Mrs. Watts, is one of the most perfect examples of colour harmony we have in England, though the floor and parts of the altar are out of tone. But the chapel is well worth a visit.

Now principles which you have learnt in large things you may apply in small. And in jewellery or metalwork so arrange your colours and ornament that they may lead up to the principal feature, and remain in subordination to it. Our scale then runs from plain metal, through repoussé work (with its lights and darks), up to enamels and stones with their hardness, brilliance and colour.

In England we have the unfortunate habit of thinking of work as weighing so many ounces of silver or of gold. We do not think enough of its artistic quality. In many cases it would be well if more than one metal were employed on a single piece of work, but this is impossible if it is to be hall-marked. The banded alloys, described in Chapter XX, give the craftsman a new manner of decorating plain surfaces at present practically unknown here, but they may be pressed into service by any one who values colour and harmony more than a hall-mark.

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not produced unless the craftsman has a share in the designing of it, or, at least, has done some original work. It is with men such as these that hope for the future rests. To encourage in our younger craftsmen this personal share in the designing has been the aim of many of our craft schools and instructors. In Birmingham, as part of the course of training for boys who propose to enter the jewellery and metal trades, Mr. Catterson Smith, Director for Art for the city, and Head Master of the Municipal School of Art, introduced a system by which lads of fourteen are encouraged to design from the first day that they touch the tools. The method is at first an adaptation for metalwork of the stamped decoration used at all times on pottery, book-covers, etc. Illustrations Figs. 339 to 358, which show a few out of thousands of examples, all different, carried out in the school, give some idea as to the course followed. The lad is given two or three repoussé tools, and shown that it is possible to make a number of interesting patterns on a piece of sheet metal by simply arranging the tool marks in groups. After one or two arrangements have been made before his eyes he is anxious to try some for himself, and very soon finds that he can make patterns at will, and that their variety is almost endless. It may be objected that to learn to make little patterns with punches will not carry a boy very far, will not make a designer of him. But short and simple though the step may be, it takes the boys past the sticking place. They know how to set about the work. That is a great point gained. Their interest is aroused, and the road to more important work then lies open before them.

In the illustrations Figs. 339 to 357 there is no break between the simple tool patterns and the more advanced work. The samplers, Figs. 339 and 340, were executed in thin metal on pitch. The face of the work shown in the illustration was, of course, in contact with the pitch, and the work done from the back. Parallel lines were ruled on the metal to facilitate the regular working of the patterns. The whole of the work

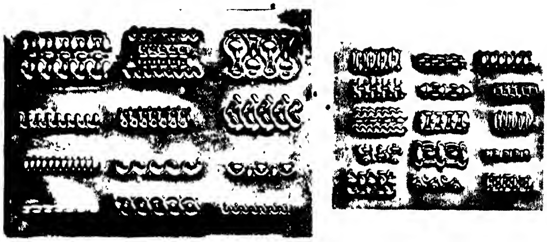
on these two samplers was done with straight and curved tracers, oval, round and triangular bossing tools, the impression showing in each case the exact shape of the tool. The curved lines in the larger sampler were ingeniously built up by the use of curved tracers of different radii. The number of good patterns which can be made in this way, with a little thought and a few tools, is very considerable. Similar stamped patterns have been used in different parts of the world ever since an early potter made a row of thumb-marks round the rim of a pot—because they pleased him. On book-covers and in many other kinds of work stamped diapers are to be met with; and similar designs may be employed now for the decoration of boxes, finger-plates, photograph frames and metal book-covers.

The next stage is shown in the two oblong plaques and in the three buttons. The impressions here still show the exact shape of the tools used. The experience gained in the planning of it—thinking out the width of the borders and spaces, the units of design to be used—makes this a valuable piece of training. Not just for the result attained in the plaques, but for the habit begun of looking for the proportion in things.

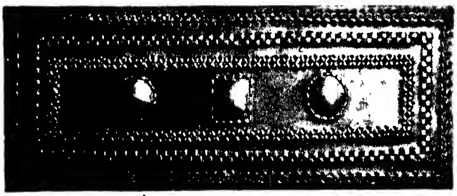
At the top of the next page the simple tool marks are beginning to be left behind. The three plaques in the first row, though the work is still done entirely from the back, show some attempt at modelling the form. When a student has got as far as this his interest is thoroughly aroused, and he will require but little encouragement to carry the work further.

Soldering is another stage. Patterns are formed from wire, plain or twisted. Grains and little bosses of metal are soon added to give variety. No. 351 shows an ingenious use of tiny metal bosses turned hollow side up and filed to represent flowers, the little grain in the centre forming the mass of the stamens. This plaque also shows the beginnings of scroll work—a "motif" which is carried further in some of the others. Fig. 357 shows the use of flattened grains as

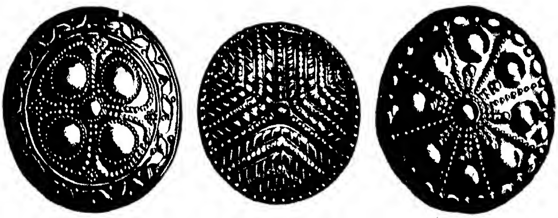
10



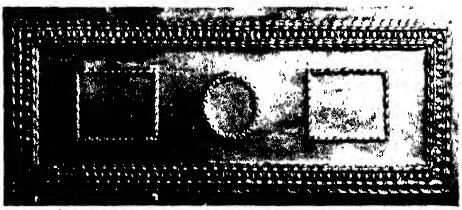
11



12–14



15



Samplers and exercises in repoussé work.

347
350

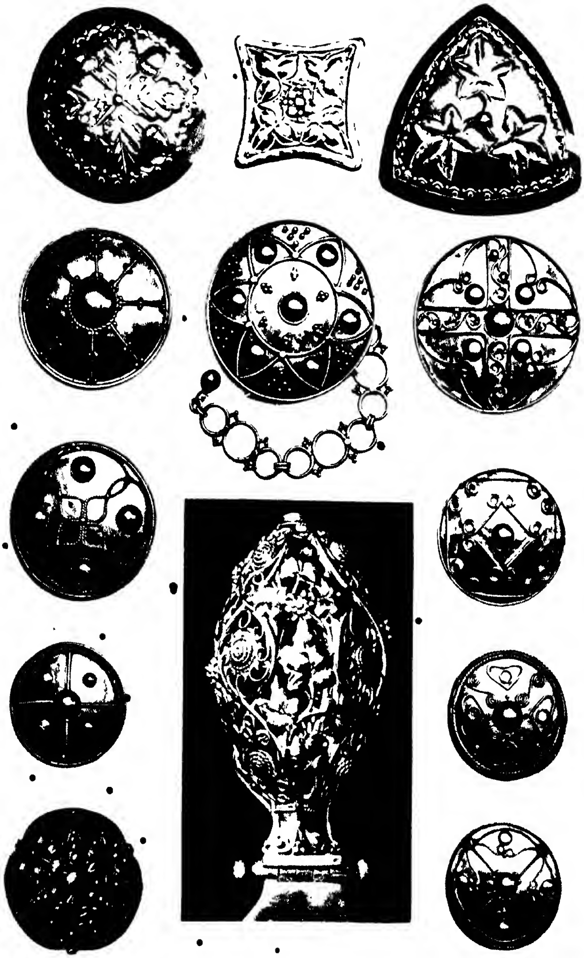
346 348

349 351

352 353

354 355

356 357



358

Exercises in soldering, repoussé, etc

a contrast to bosses. Fig. 356 gives a combination of the earlier repoussé with the wire and grain work. When a student has got thus far he will feel that design is not so hopeless a task as it looked at first. That he has much to learn he knows, but the way has opened out before him. And it looks interesting.

Mr. Rathbone, in his valuable book on *Simple Jewellery*, shows another method of making a beginning. He takes, as units of design, grains or short lengths of wire. He gives an illustration of 700 different forms each made from an inch of fine wire, and shows how some of these forms can be combined to make interesting patterns. The grains he arranges in groups of 3, 4, 5, 6 or 7, and then shows how a number of these groups may be combined.

It is by simple methods such as these that a lad may be led on step by step both in design and in craftsmanship. In the workshop alone may the true use of the material be learnt and applied.

CHAPTER XXXIII

BENVENUTO CELLINI

There is one consideration which, more than any other, the designer must bear in mind in judging the work and the craftsmen of the past. It is that a man's work must be judged on its own merit, and on that alone. Reputation is hardly a safe guide. Great reputations may be based on divers grounds; but they do not all stand quite safely on the bases generally attributed to them. Cellini's is a case in point. You have but to look into almost any book dealing with goldsmiths' work to find the name of Benvenuto Cellini tacitly accepted as that of the greatest goldsmith the world has seen. But should you endeavour to turn to his works in the craft to see upon what ground this great reputation may be based, you will meet with the initial difficulty that few examples of it have come down to us, and those which have are not specially good. Upon what Cellini's reputation is truly based it will be my endeavour to show.

First, then, let us look at the materials. Works attributed to Cellini may be seen in many of the national museums of Europe; one important example, an enamelled book-cover, being in the South Kensington Museum. Another, the great salt-cellar made for Francis I. of France, is at Vienna: other pieces are at Florence and elsewhere. M. Eugène Plon, in his great work on Cellini, illustrates all the important work by, or attributed to, the master. A copy of this book is to be found in the National Art Library at South Kensington. From it, and from an inspection of some of the works themselves, a pretty fair idea as to his attainments may be gained. Cellini also wrote two books about himself,—his autobiography and his treatises on Metalwork and Sculpture.

From them we may learn much of the man himself, his life and character.

Cellini was born in 1500; he placed himself with a goldsmith at the age of fifteen, against the desire of his father, who wished him to become a musician. As a goldsmith he worked throughout his life. But in Cellini's time the goldsmith's craft and the goldsmith's guild embraced workers in many different materials. There was no strict dividing line between goldsmith and sculptor. Luca della Robbia and Ghiberti, to mention only two famous names, began life as goldsmiths. It is not to be wondered at that Cellini also should try his hand at clay and bronze and marble. Of all the work which came from his hand Cellini was proudest of his sculptures. He described himself as sculptor, goldsmith and die-sinker.

He worked for many masters—Popes, Dukes, Cardinals, and for the King of France, producing jewels, silverware, coins, busts, statues, bas-reliefs, a figure fifty-four feet high, plans for fortifications—nothing came amiss to this most versatile man. Yet he was not a great artist in the true sense of the word. His taste was in many ways deplorable. Nearly always the craftsman overpowers the artist. He had a lack of feeling for proportion; the figures on his great salt, for instance, are too large for the rest of the work. His figures are stiff and wooden, and lack proportion, though they are often well thrown about. His work is overcrowded with detail—and this is frequently far too great in scale. The placing of the head in the coins and medals is sometimes very poor indeed. In silverwork and jewellery his work stands technically on a level with that of many of his contemporaries—neither better nor worse. In it Cellini shows no sign of transcendent genius—but rather the joy of a keen workman delighting in the overcoming of technical difficulties. But there is one sin at least which he never committed—that of thinking too little of himself and his work. By force of character he held his own among his contemporaries:

for the future he provided by his writings. But for them his name would stand far lower. He was one of the very greatest craftsmen of the sixteenth century, but he was a very poor artist. His true claims to fame are his versatile craftsmanship and literary power. Other goldsmiths have done finer work, but Benvenuto Cellini is the author of the most delightful autobiography ever written.

CHAPTER XXXIV

OUTFIT FOR A SMALL WORKSHOP

MUCH depends on the kind of work to be undertaken, some of the tools required for jewellery differing considerably from those for silversmithing, the latter being as a rule larger in size. The tools mentioned below would suffice for any ordinary piece of work which did not exceed, say, 7 inches in diameter. A more detailed list of the tools required is, however, to be found in each section of the book.

Either—	Approximate Price.
A strong bench, with top 2 to 3 inches thick, or a jeweller's bench.	
Blowpipe, about 12 inches long, with taps	12*s.*
7½ feet of rubber piping	3*s.*
Fletcher's foot blower, No. 5	33*s.*
Revolving brazing tray, 12 inch	5*s.*
Coke.	

These would all be required if raising is to be undertaken.

Or—	
Jeweller's soldering burner, with tap and rubber pipe	4*s.*
Mouth blowpipe	6*d.*
Charcoal block or wig	6*d.*

Work up to the size of a waist buckle can be soldered with these.

	Approximate Price.
Binding wire.	
Borax slate and supply of borax	9*d*.
Silver solder.	
Tweezers for solder	3*d*.
Ingot mould.	
Copper boiling-out pan.	
Sulphuric acid for pickle (for silver or copper). This acid is commonly known as vitriol.	
Leg vice, weighing not less than 65 lb. . .	30*s*.
This would not be required for jewellery work, a bench vice with 4-inch jaws, costing 12*s*., being sufficient for that.	
Two raising hammers, Figs. 128, 129	5*s*.
Planishing hammer, Fig. 132	2*s*.
Collet hammer, Fig. 133, 134 or 135	2*s*.
Horn tip, Fig. 131	1*s*. 3*d*.
These hammers are for bowlwork.	

Or—

Jeweller's hammer, Fig. 41	1*s*. 6*d*.
Boxwood mallet.	1*s*. 6*d*.
Compasses, with wing, Fig. 18	2*s*.
Stakes, see Chapter XI, for raising.	
Flat stake, to lay on board	2*s*. 6*d*.
1 pair 9-inch shears, black	2*s*. 3*d*.
1 pair 8-inch bent snips, black	3*s*. 3*d*.
Sawframe, 4-inch, Fig. 35	2*s*.
Piercing saws, 1 gross, round back, No. 2 . .	2*s*. 6*d*.
1 pair bell pliers, Fig. 29, black, 5-inch . .	1*s*. 6*d*.
1 pair flat-nosed pliers, Fig. 28, black, 5-inch .	1*s*.
2 pairs snipe-nosed pliers, Fig. 27, black, 4½-inch	2*s*.
1 pair round-nosed pliers, Fig. 26, black, 4½-inch	1*s*.
1 hand vice, Fig. 30	2*s*.
Triblets.	
1 drill stock and drills, Figs. 62 and 58 . .	6*s*.

	Approximate Price.
1 dozen needle files	1*s.* 9*d.*
½ dozen assorted files	4*s.*
½ dozen scorpers and handles	1*s.* 6*d.*
Sandbag	1*s.* 3*d.*
Drawplate and tongs	7*s.*
Eyeglass, Fig. 46	1*s.*
Pitch bowl, 9-inch, and ring	8*s.*
Pitch.	
Repoussé tools, 2 dozen	10*s.*
Leadcake	1*s.*
Burnisher	8*d.*
Polishing materials.	
Grindstone.	

CHAPTER XXXV

VARIOUS TABLES AND STANDARDS

Measures of Length

English

The yard is the distance, at 62° Fahrenheit, between two marks on a bronze bar deposited with the Board of Trade, London.

* 1 inch.
* 12 inches = 1 foot.
* 36 inches = 3 feet = 1 yard.
63360 inches = 5280 feet = 1760 yards = 1 statute mile.

Metric

The mètre is the length, at 0° Centigrade, of a platinum bar preserved at Paris, and known as the Mètre des Archives.

1 millimètre (mm.).
10 mm. = 1 centimètre (cm.).
100 mm. = 10 cm. = 1 décimètre (dm.).
1000 mm. = 100 cm. = 10 dm. = 1 mètre (m.).
1000 m. = 1 kilomètre.

Conversion Table

1 mètre = 39·37079 inches.
1 centimètre = ·3937 inches.
1 millimètre = ·03937 inches = about $\frac{1}{25}$ inch.
1 inch = 25·39977 millimètres.

* Copies of these standards are to be found on the north side of Trafalgar Square, and in the Guildhall, London.

Measures of Capacity

One litre is the volume occupied by one kilogram (2·20462 lb) of water in vacuo at 4° C.; it is very nearly a cubic decimetre.

Conversion.

1 cub. inch = 16·386 c.cm.	1 c.cm. = 0·061 cub. inch.
1 pint = 568·23 c.cm.	1 litre = 61·0363 cub. inch.
1 gallon = 4·54586 litre.	1 litre = 1·76 pint.
1 cub. foot = 28·311 litre.	1 litre = 0·2201 gallon.
1 cub. yard = 764·4 litre.	1 litre = 0·035322 cub. ft.

Measures of Weight

English

A pound (avoirdupois) is the weight of a certain piece of platinum deposited with the Board of Trade, London.

1 grain troy = 1 grain avoirdupois (gr.).
480 gr. = 1 ounce troy (oz.).
5760 gr. = 12 oz. troy = 1 pound troy.*
437·5 gr. = 1 ounce avoirdupois (oz.).
7000 gr. = 16 oz. = 1 pound avoirdupois (lb).
1 lb avoirdupois = 14 oz. 11 dwt. 16 gr. troy.

Troy weight is used in England for precious metals, *i. e.* gold, silver, etc. Avoirdupois weight is in general use for other materials.

Metric

A kilogram is the weight of a piece of platinum at Paris known as the Kilogram des Archives.

1 milligram (mgm.).
10 mgm. = 1 centigram (cgm.).
100 mgm. = 10 cgm. = 1 decigram (dgm.).
1000 mgm. = 100 cgm. = 10 dgm. = 1 gram (gm.).
1000 gm. = 1 kilogram (kilog.).

* This measurement of weight is not now used for precious metals. So the weight of 1000 ounces of gold is written thus: 1000 oz. Not 83 pounds 4 ounces Troy.

Conversion Table

1 grain = ·00208 oz. troy = ·0648 grams.

24 grains = 1 dwt. = ·05 oz. troy = 1·555 grams.

480 grains = 20 dwt. = 1 oz. troy = 31·1035 grams = 1·0971 oz. av.

437½ grains = 1 oz. av. = 28·35 grams = ·9144 oz. troy.

1 gram = 15·43235 grains = ·032151 oz. troy = ·0352736 oz. av.

1 kilog. = 2·2046 ℔ av.

The diamond carat weighs in England 3·166 grains, but in other countries it is different.

Comparative Table of Troy and Avoirdupois Weight.

Avoirdupois.	Troy			Avoirdupois.	Troy.		
¼ oz. =		4 dwt.	13⅜ gr.	8 oz. =	7 oz.	5 dwt.	20 gr.
½ ,, =		9 ,,	2¾ ,,	9 ,, =	8 ×	4 ,,	1½ ,,
1 ,, =		18 ,,	5½ ,,	10 ,, =	9 ,,	2 ,,	7 ,,
2 ,, =	1 oz.	16 ,,	11 ,,	11 ,, =	10 ,,	0 ,,	12½ ,,
3 ,, =	2 ,,	14 ,,	16½ ,,	12 ,, =	10 ,,	18 ,,	18 ,,
4 ,, =	3 ,,	12 ,,	22 ,,	13 ,, =	11 ,,	16 ,,	23½ ,,
5 ,, =	4 ,,	11 ,,	3½ ,,	14 ,, =	12 ,,	15 ,,	5 ,,
6 ,, =	5 ,,	9 ,,	9 ,,	15 ,, =	13 ,,	13 ,,	10½ ,,
7 ,, =	6 ,,	7 ,,	14½ ,,	16 ,, =	14 ,,	11 ,,	16 ,,

192 oz. (12 ℔) avoirdupois = 175 oz. troy = 84,000 gr.

Measures of Temperature

There are three entirely different scales to which thermometers are divided. They are known by the names of Fahrenheit, Centigrade and Réaumur, the first and third being called after their authors. The Fahrenheit scale is largely used in this country. The Centigrade is in general use among scientists, and in countries which use the decimal standards. The Réaumur scale is extensively used in Germany.

The three scales are divided so :—

Fahrenheit

212°. Water boils.
32°. Freezing point (melting ice).
0°. Zero.

There are thus 180° between the freezing and boiling points.

Centigrade

100°. Water boils.
0°. Freezing point (melting ice). Zero.

There are 100° on this scale between the freezing and boiling points.

Réaumur

80°. Water boils.
0°. Zero. Freezing point (melting ice).

Temperatures are met with which run into thousands of degrees. They cannot, however, be measured by ordinary thermometers. On page 304 a rough method of reckoning high temperatures is given.

CONVERSION TABLE

Fahrenheit to Centigrade.

The formula is: $(F - 32)\,\frac{5}{9} = C$.

F represents the temperature on the Fahrenheit scale, and C the temperature on the Centigrade.

The formula may be put thus:—Subtract 32 from the number of degrees Fahrenheit. Multiply the result by 5, and divide by 9. The result will be in degrees Centigrade.

Examples.—(*a*). Find the place on the Centigrade scale corresponding to 86° F.—Answer. Subtract 32° from 86°. This makes 54° F. above freezing point. Multiply 54 by 5 and divide by 9. Thus $54 \times \frac{5}{9} = 30$. Result, 30° C.

(*b*) To what temperature on the Centigrade thermometer does − 13° F. correspond?—Answer. Subtract 32° from − 13. This makes − 45°. Multiply − 45 by 5, and divide by 9. Result, − 25° C.

Centigrade to Fahrenheit.

The formula is: $\frac{9C}{5} + 32 = F.$

It may be put thus:—Multiply the number of degrees Centigrade by 9, divide by 5, add 32; and the result is in degrees Fahrenheit.

Examples.—(*c*) Find on the Fahrenheit scale the temperature corresponding to 45° C.—Answer. 9 times 45 are 405. Divide 405 by 5. Result, 81. Add 32 to 81. Total, 113. Therefore 113° F. corresponds to 45° C.

(*d*) What temperature Fahrenheit corresponds to − 40° C.—Answer. The temperature is 40 × $\frac{9}{5}$ = 72° F. below the freezing point (32° F.). Or 40° F. below the zero of Fahrenheit. Therefore − 40° C = − 40° F.

The formula for the reduction of Centigrade to Réaumur is: $\frac{4C}{5} = R.$

To reduce Réaumur to Centigrade it is: $\frac{5R}{4} = C.$

MEASURES OF LENGTH.

English

Inches.	Millimètres.	Decimals of an inch.	Inches.	Millimètres.	Decimals of an inch.
$\frac{1}{64}$	·39687	·01563	$\frac{17}{32}$	13·49362	·53125
$\frac{1}{32}$	·79374	·03125	$\frac{9}{16}$	14·28737	·5625
$\frac{1}{16}$	1·58748	·0625	$\frac{19}{32}$	15·08111	·59375
$\frac{3}{32}$	2·38123	·09375	$\frac{5}{8}$	15·87485	·625
$\frac{1}{8}$	3·17497	·125	$\frac{21}{32}$	16·66859	·65625
$\frac{5}{32}$	3·96871	·15625	$\frac{11}{16}$	17·46234	·6875
$\frac{3}{16}$	4·76245	·1875	$\frac{23}{32}$	18·25608	·71875
$\frac{7}{32}$	5·55620	·21875	$\frac{3}{4}$	19·04982	·750
$\frac{1}{4}$	6·34994	·250	$\frac{25}{32}$	19·84356	·78125
$\frac{9}{32}$	7·14368	·28125	$\frac{13}{16}$	20·63731	·8125
$\frac{5}{16}$	7·93743	·3125	$\frac{27}{32}$	21·43105	·84375
$\frac{11}{32}$	8·73117	·34375	$\frac{7}{8}$	22·22479	·875
$\frac{3}{8}$	9·52491	·375	$\frac{29}{32}$	23·01853	·90625
$\frac{13}{32}$	10·31865	·40625	$\frac{15}{16}$	23·81228	·9375
$\frac{7}{16}$	11·11240	·4375	$\frac{31}{32}$	24·60602	·96875
$\frac{15}{32}$	11·90614	·46875	1	25·39977	1·000
$\frac{1}{2}$	12·69988	·50			

Decimal Fractions of an Inch in Millimètres.

in.	mm.	in.	mm.	in.	mm.
·01	·254	·35	8·890	·68	17·272
·02	·508	·36	9·114	·69	17·526
·03	·762	·37	9·398	·70	17·780
·04	1·016	·38	9·652	·71	18·034
·05	1·270	·39	9·906	·72	18·288
·06	1·524	·40	10·160	·73	18·542
·07	1·778	·41	10·414	·74	18·796
·08	2·032	·42	10·668	·75	19·050
·09	2·286	·43	10·922	·76	19·304
·10	2·540	·44	11·176	·77	19·558
·11	2·794	·45	11·430	·78	19·812
·12	3·048	·46	11·684	·79	20·066
·13	3·302	·47	11·938	·80	20·320
·14	3·556	·48	12·192	·81	20·574
·15	3·810	·49	12·446	·82	20·828
·16	4·064	·50	12·700	·83	21·082
·17	4·318	·51	12·954	·84	21·336
·18	4·572	·52	13·208	·85	21·590
·19	4·826	·53	13·462	·86	21·844
·20	5·080	·54	13·716	·87	22·098
·21	5·334	·55	13·970	·88	22·352
·22	5·588	·56	14·224	·89	22·606
·23	5·842	·57	14·478	·90	22·860
·24	6·096	·58	14·732	·91	23·114
·25	6·350	·59	14·986	·92	23·368
·26	6·604	·60	15·240	·93	23·622
·27	6·858	·61	15·494	·94	23·876
·28	7·112	·62	15·748	·95	24·130
·29	7·366	·63	16·002	·96	24·384
·30	7·620	·64	16·256	·97	24·638
·31	7·874	·65	16·510	·98	24·892
·32	8·128	·66	16·764	·99	25·146
·33	8·382	·67	17·018	1·00	25·400
·34	8·636				

Pennyweights and Grains with Decimals of oz. Troy.				Troy Weight with Milligrams.	
Dwts.	Decimals.	Grains.	Decimals.	Oz.	Milligrams.
20	1·000	24	·050	·001	31·1035
19	·950	23	·047916	·002	62·2070
18	·900	22	·045833	·003	93·3105
17	·850	21	·04375	·004	124·4140
16	·800	20	·041083	·005	155·5175
15	·750	19	·039	·010	311·0350
14	·700	18	·0375	·020	622·070
13	·650	17	·035416	·030	933·1050
12	·600	16	·033	·040	1244·140
11	·550	15	·03125	·050	1555·1750
10	·500	14	·012966	·10	3110·350
9	·450	13	·027083	·20	6220·700
8	·400	12	·025	·30	9331·050
7	·350	11	·022916	·40	12441·40
6	·300	10	·020833	·50	15551·750
5	·250	9	·01875	·75	23327·625
4	·200	8	·01666	1·0	31103·50
3	·150	7	·014583		
2	·100	6	·0125		
1	·050	5	·010416		
		4	·00833		
		3	·00625		
		2	·004166		
		1	·002083		

1·0 oz. = 31·1035 grams.

Equivalent Value Millimètres and Inches.					
Millimètres.	Inches.	Millimètres.	Inches.	Millimètres.	Inches.
1	·0394	10	·3937	19	·7480
2	·0787	11	·4331	20	·7874
3	·1181	12	·4724	21	·8268
4	·1575	13	·5118	22	·8661
5	·1968	14	·5512	23	·9055
6	·2362	15	·5906	24	·9449
7	·2756	16	·6299	25	·9843
8	·3150	17	·6693	26	1·0236
9	·3543	18	·7087		

Properties of Circles.

1. Diameter × 3·14159 = circumference.

To find the circumference, *i. e.* the distance round the edge of a circle, multiply its diameter by $3\frac{1}{7}$. Thus, if the top of a bowl measures 7 inches across it will measure 22 inches round the edge. This rule is a very important one, as it is used so frequently. Three and one-seventh is

the nearest easy fraction to 3·14159, and it gives results correctly enough for practical purposes.

2. Diameter squared × ·7854 = area of circle.

To find the area of a circle. Multiply its diameter by itself and the result by ·7854. Thus for a circle 10 inches in diameter. Multiply 10 by itself, 10 × 10 = 100 square inches. Multiply 100 square inches by ·7854. The result is 78·54 inches—a little over 78½ square inches, which is the area of a circle measuring 10 inches across the middle.

The two next sets of tables, which give the area of circles from 1 inch diameter up to 25 inches, and the weight in silver per square inch for every size on the metal gauge, can be used thus. To find the weight of a circle of silver 8 inches in diameter, size 12 on the metal gauge. The area of a circle 8 inches in diameter is a little over 50¼ inches. A square inch of silver, size 12, weighs ·203 of an ounce. 50¼ multiplied by ·203 of an ounce gives 10·20 ounces (10⅕ oz.), which is the approximate weight of a circle of silver 8 inches in diameter, size 12.

AREAS OF CIRCLES.

Diameter.	Area.	Diameter.	Area.	Diameter.	Area.
1 in.	·7854	4½ ins.	15·9043	12½ ins.	122·718
1⅛ ,,	·9940	4¾ ,,	17·7205	13 ,,	132·732
1¼ ,,	1·2271	5 ,,	19·6350	13½ ,,	143·139
1⅜ ,,	1·4848	5¼ ,,	21·6475	14 ,,	153·938
1½ ,,	1·7671	5½ ,,	23·7583	14½ ,,	165·130
1⅝ ,,	2·0739	5¾ ,,	25·9672	15 ,,	176·715
1¾ ,,	2·4052	6 ,,	28·2744	15½ ,,	188·692
1⅞ ,,	2·7611	6¼ ,,	30·6796	16 ,,	201·062
2 ins.	3·1416	6½ ,,	33·1831	16½ ,,	213·825
2⅛ ,,	3·5465	6¾ ,,	35·7847	17 ,,	226·980
2¼ ,,	3·9760	7 ,,	38·4846	17½ ,,	240·528
2⅜ ,,	4·4302	7½ ,,	44·1787	18 ,,	254·469
2½ ,,	4·9087	8 ,,	50·2656	18½ ,,	268·803
2⅝ ,,	5·4119	8½ ,,	56·7451	19 ,,	283·529
2¾ ,,	5·9395	9 ,,	63·6174	19½ ,,	298·648
2⅞ ,,	6·4918	9½ ,,	70·8823	20 ,,	314·180
3 ,,	7·0686	10 ,,	78·5400	21 ,,	346·361
3¼ ,,	8·2957	10½ ,,	86·5903	22 ,,	380·133
3½ ,,	9·6211	11 ,,	95·0334	23 ,,	415·476
3¾ ,,	11·0446	11½ ,,	103·869	24 ,,	452·390
4 ,,	12·5664	12 ,,	113·097	25 ,,	490·875
4¼ ,,	14·1862				

Approximate Weight of 1 Square Inch of Silver to the Various Sizes on the Birmingham Metal Gauge.

Gauge size.	Approximate weight per square inch.				Gauge size.	Approximate weight per square inch.			
	Decimals of oz.		dwt.	gr.		Decimals of oz.		dwt.	gr.
1	·049	or	–	23½	13	·220	or	4	9½
2	·055	,,	1	1½	14	·246	,,	4	22
3	·061	,,	1	5	15	·268	,,	5	8½
4	·070	,,	1	10	16	·286	,,	5	17½
5	·081	,,	1	14½	17	·307	,,	6	3½
6	·093	,,	1	20½	18	·330	,,	6	14½
7	·110	,,	2	5	19	·342	,,	6	20
8	·126	,,	2	12½	20	·362	,,	7	6
9	·143	,,	2	20½	21	·384	,,	7	16½
10	·163	,,	3	6½	22	·406	,,	8	3
11	·183	,,	3	16	23	·428	,,	8	13½
12	·203	,,	4	1½	24	·456	,,	9	3

Weight of Metals in Pounds per Square Foot.

Thickness in Standard Wire Gauge.

S.W.G. of sheet.	Thickness in decimals of an inch.	Copper.	Brass.	Aluminium.
0	·324	14·91	14·44	4·50
1	·300	13·82	13·38	4·17
2	·276	12·74	12·32	3·84
3	·252	11·60	11·26	3·51
4	·232	10·70	10·36	3·08
5	·212	9·78	9·47	2·81
6	·192	8·84	8·57	2·54
7	·176	8·11	7·85	2·34
8	·160	7·38	7·13	2·12
9	·144	6·62	6·41	1·91
10	·128	5·90	5·71	1·70
11	·116	5·33	5·18	1·54
12	·104	4·80	4·64	1·38
14	·080	3·68	3·57	1·06
16	·064	2·95	2·86	0·849
18	·048	2·21	2·15	0·637
20	·036	1·66	1·61	0·477
22	·028	1·29	1·25	0·371
24	·022	1·015	0·982	0·292
26	·018	0·830	0·804	0·239
28	·015	0·644	0·625	0·186
30	·012	0·552	0·536	0·159
32	·011	0·461	0·447	0·133
34	·009	0·415	0·402	0·120
36	·008	0·322	0·313	0·093

The Composition of Various Alloys.

Aluminium bronze	9 parts copper	1 part aluminium	Best alloy for general purposes.
Bell metal	3 to 5 ,, ,,	1 ,, tin	
Brass	7 ,, ,,	3 parts zinc	For sheet metal and casting. Good colour.
,, white	7 ,, ,,	13 ,, zinc	Silver white colour.
Bronze coinage	95 ,, ,,	4 ,, tin, 1 part zinc	English standard.
Bronze, malleable	19 ,, ,,	1 part tin.	
Bronze, statuary	90 ,, ,,	6 parts tin, 3 zinc, 1 part lead	The best mixture for fine castings.
German silver	23 ,, ,,	17 ,, nickel, 10 parts zinc	Best alloy, but expensive owing to cost of nickel.
,,	20 ,, ,,	6 ,, nickel, 8 parts zinc.	
Gilding metal	5 ,,	1 part zinc.	
Gold	9 ,, gold	2 parts silver, 1 part copper	18 carat gold. Rather pale.
,,	36 ,, ,,	7 ,, silver, 5 parts ,,	18 carat old. Redder.
Gold coinage	22 ,, ,,	2 ,, copper	English standard (22 carat).
Gun metal	9 ,, copper	1 part tin	Strongest alloy. Zinc sometimes added. The preparation of copper varies from 16 c. to 5c. to 1 of tin.
Pewter	4 ,, tin	1 ,, lead	Common. Other metal sometimes added.
,,	12 ,, ,,	1 ,, antimony.	
Silver coinage	222 ,, silver	18 parts copper	English standard.
Silver solder	3 ,, ,,	1 part brass wire	Good and strong.
,,	2 ,, ,,	1 ,, brass wire or pins	
Soft solder	2 ,, tin	1 ,, lead	Good.
,,	1 part ,,	2 parts ,,	Plumbers'. For wiping joints.
Speculum metal	2 parts copper	1 part tin	Perfectly white. Takes good polish.
Spelter for brazing	1 part ,,	1 ,, zinc.	Strong.
,, ,,	1 ,, ,,	2 parts zinc	More fusible. Weaker than the other.
Fusible metal for small casts	13 parts lead	3 ,, zinc, 6 parts bismuth.	Very sharp casts.

For other alloys see *Mixed Metals and Metallic Alloys*, by A. H. Hiorns.

THE MELTING POINTS AND ATOMIC WEIGHTS OF VARIOUS MATERIALS.

Name.	Cent.	Fahr.	Atomic weight.
Aluminium	657°	1215°	27·1
Antimony	625	1157	120·2
Bismuth	267	513	208
Brass	1015 ? varies	1859 ?	
Cadmium	321	610	112·4
Copper	1083	1981	63·57
Gold	1062	1944	197·2
Ice	0	32	
Iridium	2500	4532	193·1
Cast-iron	1100 ? varies	2012 ?	
Iron (pure)	1500	2732	55·85
Lead	327	621	207·1
Magnesium	333	1167	24·32
Mercury (solid)	− 39·5	− 39	200
Nickel	1480	2698	58·68
Platinum	1750	3182	194·9
Silver	961	1762	107·88
Steel	1350 ? varies	2462 ?	
Tin	232	450	119
Water (boils)	100	212	
Zinc	419	786	65·4
Common salt	801	1474	

The figures given above are for fine gold, fine silver, fine copper, etc. Those for alloys would differ.

A ROUGH METHOD OF ESTIMATING HIGH TEMPERATURE.

Degrees Cent.	
232.	Tin melts.
419.	Zinc melts.
600.	Faint red glow.
700.	Dull red.
800.	Cherry red.
900.	Bright red.
961.	Fine silver melts.
1000.	Very bright red, verging into yellow.
1062.	Fine gold melts.
1083.	Fine copper melts.
1280.	White heat.
c. 1350.	Steel melts.
1480.	Nickel melts. Blinding white.
1500.	Iron melts.
1750.	Platinum melts.

Temperature Obtainable in—

	Degrees Cent.
Bunsen burner flame	1100–1350
Méker burner flame	1450–1600
Petrol blowlamp flame	1500–1600
Oxy-hydrogen flame	about 2000
Oxy-acetylene flame	„ 2400
Electric arc	„ 3500
Electric arc (under pressure)	„ 3600
Sun	„ 5500

Weight and Specific Gravity of Metals.

	Troy oz.	Specific gravity.
If platinum of given dimensions weighs	1·0	21·50
Fine gold of same dimensions will weigh	·900	19·33
22 carat	·820	17·60
20 „	·765	16·50
18 „	·725	15·55
15 „	·645	13·50
12 „	·590	12·75
9 „	·535	11·50
6 „	·505	10·90
Silver, fine	·495	10·70
Silver, standard	·490	10·50
Lead	·530	11·40
Bismuth	·455	9·80
Copper	·415	8·95
Nickel	·414	8·90
Brass	·375	8·10
Iron	·365	7·85
Tin	·340	7·30
Zinc	·335	7·15
Aluminium	·120	2·60

WHITWORTH STANDARD 55° SCREW THREADS FOR BOLTS.

Diameter of bolt. Fractional sizes.	Diameter of bolt. Decimal sizes.	Number of threads per inch	Diameter at bottom of thread.
$\frac{1}{16}$	·0625	60	·0411
$\frac{3}{32}$	·09375	48	·0670
$\frac{1}{8}$	·125	40	·0929
$\frac{3}{16}$	·1875	24	·1341
$\frac{1}{4}$	·25	20	·1859
$\frac{5}{16}$	·3125	18	·2413
$\frac{3}{8}$	·375	16	·2949
$\frac{7}{16}$	·4375	14	·3460
$\frac{1}{2}$	·5	12	·3932
$\frac{9}{16}$	.5625	12	·4557
$\frac{5}{8}$	.625	11	·5085
$\frac{11}{16}$	·6875	11	·5710
$\frac{3}{4}$	·75	10	·6219
$\frac{13}{16}$	·8125	10	·6844
$\frac{7}{8}$	·875	9	·7327
$\frac{15}{16}$	·9375	9	·7952
1	1·0	8	·8399
$1\frac{1}{8}$	1·125	7	·9420
$1\frac{1}{4}$	1·25	7	1·0670
$1\frac{3}{8}$	1·375	6	1·1615
$1\frac{1}{2}$	1·5	6	1·2865
$1\frac{5}{8}$	1·625	5	1·3688
$1\frac{3}{4}$	1·75	5	1·4938
$1\frac{7}{8}$	1·875	4·5	1·5904
2	2·0	4·5	1·7154
$2\frac{1}{2}$	2·5	4	2·1798
3	3·0	3·5	2·6340
4	4·0	3	3·5731
5	5·0	2·75	4·5343
6	6·0	2·5	5·4877

The standard Whitworth thread is inclined at an angle of 55°, one-six at top and bottom of thread being cut off and rounded.

British Association (B.A.) Gauge for Apparatus Screws.

This is adopted as the Standard Screw Gauge by Post Office Telegraphs Department and most large Electrical Firms

No.	Nominal dimensions in thousandths of an inch.		Threads per inch.	Absolute dimensions in millimètres.	
	Diameter.	Pitch.		Diameter.	Pitch.
25	10	2·8	353	0·25	0·072
24	11	3·1	317	0·29	0·080
23	13	3·5	285	0·33	0·089
22	15	3·9	259	0·37	0·098
21	17	4·3	231	0·42	0·11
20	19	4·7	212	0·48	0·12
19	21	5·5	181	0·54	0·14
18	24	5·9	169	0·62	0·15
17	27	6·7	149	0·70	0·17
16	31	7·5	134	0·79	0·19
15	35	8·3	121	0·90	0·21
14	39	9·1	110	1·0	0·23
13	44	9·8	101	1·2	0·25
12	51	11·0	90·7	1·3	0·28
11	59	12·2	81·9	1·5	0·31
10	67	13·8	72·6	1·7	0·35
9	75	15·4	65·1	1·9	0·39
8	86	16·9	59·1	2·2	0·43
7	98	18·9	52·9	2·5	0·48
6	110	20·9	47·9	2·8	0·53
5	126	23·2	43·0	3·2	0·59
4	142	26·0	38·5	3·6	0·66
3	161	28·7	34·8	4·1	0·73
2	185	31·9	31·4	4·7	0·81
1	209	35·4	28·2	5·3	0·90
0	236	39·4	25·4	6·0	1·00

CHAPTER XXXVI

GAUGES

THE thickness of a sheet of metal, or of a wire, is measured by a tool known as a gauge. This often takes the form of an oblong or circular sheet of steel with a number of slits cut round its edge. The slits are numbered, and they vary in width in regular order, from quite narrow ones, too small to admit the edge of a sheet of writing-paper, up to ¼ inch or more. In England there is, unfortunately, no standard gauge for all materials. In buying metal it is therefore advisable to mention which gauge you are using. For sheet gold, silver and copper, the "metal" gauge, that is to say, the Birmingham metal gauge, is generally, though not always, used.

In the following pages, where the principal gauges in use for metalwork are printed in parallel columns, equal measurements are placed immediately opposite to each other.

To transfer a given thickness from one gauge to another it is only necessary to glance across the page, and the exact, or the nearest, equivalent will be found, in its proper column, opposite. Thus, the nearest equivalent on the Birmingham Wire Gauge to size 14 on the Metal Gauge is No. 19, B.W.G. It differs by only one-thousandth of an inch in thickness.

Size 11 on the Metal Gauge is the same thickness as No. 21, Standard Wire Gauge, or 21, B.W.G., or 66 on Stubs' Steel Wire Gauge, and 67 on the Morse Twist Drill and Steel Wire Gauge. It is 32 thousandths of an inch, or ·81 millimètre, in thickness.

In the first column the thickness is given in decimals of

an inch. Thus ·500 represents a thickness of half an inch, or 500 thousandth parts of an inch ; ·464 means 464 thousandths of an inch, and so on. A measurement like ·2055 represents 2055 ten-thousandths of an inch or 205½ thousandths of an inch.

In the second column are given the sizes on the Birmingham Metal Gauge. This gauge is the one generally used for sheet gold and silver. It is also used for copper, brass, etc. Gold- and silver-smiths use it almost exclusively. Throughout this book it has been constantly referred to as "the metal gauge."

The third column gives the Imperial Standard Wire Gauge. It is very generally used for wire or sheet metal.

In the fourth column is the Morse Twist Drill and Steel Wire Gauge. Large numbers of American Twist Drills are made to this gauge.

The fifth and sixth columns give Stubs' Iron Wire Gauge and Stubs' Steel Wire Gauge. In using these gauges the difference between the two should be constantly borne in mind. The Stubs' Iron Wire Gauge is commonly known as the Birmingham Wire Gauge, sometimes as the English Standard Wire or Soft Wire Gauge. It is much used for iron, copper or brass wire. The Stubs' Steel Wire Gauge is used for measuring drawn steel wire or drill rods of Stubs' make, and has been adopted by many makers of American drills.

The last column gives the thickness in millimètres.

It is well to keep to one gauge as much as possible. A metalworker, goldsmith or silversmith, can get on quite well with the Birmingham Metal Gauge. It is in general use in the trade for measuring gold and silver. But he must not use it when buying steel wire or drills, or sheet iron, or aluminium, or many other things, unless he makes it quite clear to the salesman that he is using just that gauge.

Gauges, again, get worn. The sheet of metal to be measured may fit tightly or loosely into the slot. Its

extreme edge may be expanded by rough usage and so the sheet will appear to be thicker than it really is. All these things cause uncertainty as to the thickness of metal supplied you. The only way to make quite sure is by using a micrometer gauge. These convenient little tools measure thicknesses by means of a screw and vernier. One which will take any size up to a quarter of an inch, by one-thousandths of an inch, can be bought for about five shillings. If you have one of those you are independent of all the other gauges. For the first column in the table below gives you the number of thousandths of an inch to which you must set the micrometer to correspond with any number on either of the other gauges. Thus ·250 means 250 thousandths of an inch, or ¼ inch; ·055 in the first column means 55 thousandths of an inch. If you set the micrometer to that, it will correspond with size 17 on the Birmingham Metal Gauge, and No. 54 on both the Morse Twist Drill Gauge and Stubs' Steel Wire Gauge; ·0095 means 9·5 or 9½ thousandths of an inch. It is 95 ten-thousandths of an inch; ·0080 is 8 thousandths of an inch or 80 ten-thousandths of an inch—which is the same thing. Micrometers to measure in ten-thousandths of an inch, are considerably more expensive than those which go only to thousandths. But they are unnecessary except for very fine scientific work.

Comparative Table of the Various Gauges.

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morse Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge	Millimètres.
·500	...	7/0	...	...	...	12·70
·464	...	6/0	...	...	...	11·79
·454	...	...	...	0000	...	11·53
·432	...	5/0	...	...	...	10·97
·425	...	...	...	000	...	10·79
·413	...	...	...	...	Z	10·49
·404	...	...	...	...	Y	10·26
·400	...	4/0	...	...	...	10·16
·397	...	...	...	...	X	10·08

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morse Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Millimètres.
·386	...	...	...	...	W	9·80
·380	...	...	...	00	...	9·65
·377	...	...	...	...	V	9·58
·372	...	3/0	...	...	...	9·45
·368	...	...	...	...	U	9·35
·358	...	...	...	...	T	9·09
·348	...	2/0	...	...	S	8·84
·340	...	...	...	0	...	8·64
·339	...	...	...	...	R	8·61
·332	...	...	...	...	Q	8·43
·324	...	1/0	...	...	...	8·23
·323	...	...	...	...	P	8·20
·316	...	...	...	...	O	8·03
·302	...	...	...	...	N	7·67
·300	...	1	...	1	...	7·62
·295	...	...	...	...	M	7·49
·290	...	...	...	...	L	7·37
·284	...	...	...	2	...	7·21
·281	...	...	...	...	K	7·14
·277	...	...	...	...	J	7·04
·276	...	2	...	...	...	7·01
·272	...	...	...	...	I	6·91
·266	...	...	...	...	H	6·76
·261	...	...	...	...	G	6·63
·259	...	...	...	3	...	6·58
·257	...	...	...	...	F	6·53
·252	...	3	...	...	...	6·40
·250	...	...	...	...	E	6·35
·246	...	...	...	...	D	6·25
·242	...	...	...	...	C	6·15
·238	...	...	...	4	B	6·04
·234	...	...	...	...	A	5·94
·232	...	4	...	...	...	5·89
·228	...	...	1	...	...	5·79
·227	...	...	...	...	1	5·77
·221	...	...	2	...	...	5·61
·220	...	...	...	5	...	5·59
·219	...	...	...	...	2	5·56
·213	...	...	3	...	3	5·41
·212	...	5	...	...	...	5·38
·209	...	...	4	...	...	5·31
·207	...	...	...	...	4	5·26
·2055	...	...	5	...	...	5·22
·204	...	...	6	...	5	5·18
·203	...	...	...	6	...	5·16
·201	...	...	7	...	6	5·11

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morse Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Milli-mètres.
·199	...	...	8	...	7	5·06
·197	...	...	...	...	8	5·01
·196	...	...	9	...	...	4·98
·194	...	...	...	...	9	4·93
·1935	...	...	10	...	...	4·91
·192	...	6	...	...	...	4·88
·191	...	...	11	...	10	4·86
·189	...	...	12	...	...	4·80
·188	...	...	...	...	11	4·78
·185	...	...	13	...	12	4·70
·182	...	...	14	...	13	4·62
·180	...	...	15	7	14	4·57
·178	...	...	...	...	15	4·52
·177	...	...	16	...	...	4·50
·176	...	7	...	...	...	4·47
·175	...	...	...	...	16	4·44
·173	...	...	17	...	...	4·39
·172	...	...	...	...	17	4·37
·1695	...	...	18	...	...	4·31
·168	...	...	...	...	18	4·27
·166	...	...	19	...	...	4·22
·165	...	...	...	8	...	4·19
·164	...	...	...	...	19	4·17
·161	...	...	20	...	20	4·09
·160	...	8	...	...	...	4·06
·159	...	...	21	...	...	4·04
·157	...	...	22	...	21	3·99
·155	...	...	...	...	22	3·94
·154	...	...	23	...	...	3·91
·153	...	...	...	...	23	3·89
·152	...	...	24	...	...	3·86
·151	...	...	...	...	24	3·84
·1495	...	...	25	...	...	3·80
·148	...	...	...	9	25	3·76
·147	...	...	26	...	...	3·73
·146	...	...	...	...	26	3·71
·144	...	9	27	...	...	3·66
·143	...	...	...	...	27	3·63
·1405	...	...	28	...	...	3·57
·139	...	...	...	...	28	3·53
·136	...	...	29	...	...	3·45
·134	...	...	...	10	29	3·40
·1285	...	...	30	...	...	3·26
·128	...	10	...	...	...	3·25
·127	...	...	...	...	30	3·23
·120	...	...	31	11	31	3·05

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morse Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Milli-mètres.
·116	...	11	32	...	...	2·95
·115	...	...	...	...	32	2·92
·113	...	...	33	...	...	2·87
·112	...	...	...	...	33	2·84
·111	...	...	34	...	...	2·82
·110	...	...	35	...	34	2·79
·109	...	...	...	12	...	2·77
·108	...	...	...	...	35	2·74
·1065	...	...	36	...	...	2·70
·106	...	...	...	...	36	2·69
·104	...	12	37	...	...	2·64
·103	...	...	...	...	37	2·62
·1015	...	...	38	...	...	2·58
·101	...	...	...	...	38	2·57
·0995	...	...	39	...	...	2·53
·099	...	...	...	...	39	2·51
·098	...	...	40	...	...	2·49
·097	...	...	...	...	40	2·46
·096	...	...	41	...	...	2·44
·095	...	...	...	13	41	2·41
·0935	...	...	42	...	...	2·37
·092	...	13	...	...	42	2·34
·089	...	...	43	...	...	2·26
·088	...	...	...	...	43	2·24
·086	...	...	44	...	...	2·18
·085	...	...	...	...	44	2·16
·083	...	...	...	14	...	2·11
·082	24	...	45	...	...	2·08
·081	...	...	46	...	45	2·06
·080	...	14	...	...	...	2·03
·079	...	...	...	...	46	2·01
·0785	...	...	47	...	...	1·99
·077	23	...	...	...	47	1·96
·076	...	...	48	...	...	1·93
·075	...	...	...	...	48	1·90
·073	22	...	49	...	...	1·85
·072	...	15	...	15	49	1·83
·070	...	...	50	...	...	1·78
·069	21	...	...	...	50	1·75
·067	...	...	51	...	...	1·70
·066	...	...	...	...	51	1·68
·065	20	...	...	16	...	1·65
·064	...	16	...	...	...	1·63
·0635	...	...	52	...	...	1·61
·063	...	...	...	...	52	1·60
·062	19	...	...	...	...	1·57

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morre Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Milli-mètres.
·0595	...	...	53	...	...	1·51
·059	18	...	...	...	...	1·50
·058	...	...	...	17	53	1·47
·056	...	17	...	...	...	1·42
·055	17	...	54	...	54	1·40
·052	...	...	55	...	...	1·32
·051	16	...	...	...	...	1·30
·050	...	...	...	...	55	1·27
·049	...	...	...	18	...	1·24
·048	15	18	...	...	...	1·22
·0465	...	...	56	...	...	1·18
·045	...	...	...	...	56	1·14
·043	14	...	57	...	...	1·09
·042	...	...	58	19	57	1·07
·041	...	...	59	...	58	1·04
·040	...	19	60	...	59	1·02
·039	...	...	61	...	60	·99
·038	13	...	62	...	61	·97
·037	...	...	63	...	62	·94
·036	...	20	64	...	63	·91
·035	12	...	65	20	64	·89
·033	...	...	66	...	65	·84
·032	11	21	67	21	66	·81
·031	...	...	68	...	67	·79
·030	...	...	...	...	68	·76
·02925	...	...	69	...	...	·74
·029	...	...	...	...	69	·74
·028	10	22	70	22	...	·71
·027	...	...	...	...	70	·69
·026	...	...	71	...	71	·66
·025	...	...	72	23	...	·63
·024	9	23	73	...	72	·61
·023	...	...	...	...	73	·58
·0225	...	...	74	...	...	·57
·022	...	24	...	24	74	·56
·0215	8	...	...	...	...	·55
·021	...	...	75	...	...	·53
·020	...	25	76	25	75	·51
·019	7	...	...	...	...	·48
·018	...	26	77	26	76	·46
·0164	...	27	...	...	...	·42
·016	6	...	78	27	77	·41
·015	...	...	...	...	78	·38
·0148	...	28	...	...	...	·38
·0145	...	...	79	...	...	·37
·0140	5	...	...	28	79	·36

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morse Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Millimètres.
·0136	...	29	...	...	...	·35
·0135	...	...	80	...	...	·34
·0130	...	...	...	29	80	·33
·0124	...	30	...	...	...	·31
·0120	4	...	...	30	...	·30
·0116	...	31	...	...	...	·295
·0108	...	32	...	...	...	·274
·0105	3	...	...	...	...	·267
·0100	...	33	...	31	...	·254
·0095	2	...	...	...	...	·241
·0092	...	34	...	...	...	·234
·0090	...	...	...	32	...	·229
·0085	1	...	...	...	...	·216
·0084	...	35	...	...	...	·213
·0080	...	...	...	33	...	·203
·0076	...	36	...	...	...	·193
·0070	...	...	...	34	...	·178
·0068	...	37	...	...	...	·173
·0060	...	38	...	...	...	·152
·0052	...	39	...	...	...	·132
.0050	...	...	...	35	...	·127
·0048	...	40	...	...	...	·122
·0044	...	41	...	...	...	·112
·0040	...	42	...	36	...	·102
·0036	...	43	...	...	...	·091
·0032	...	44	...	...	...	·081
·0028	...	45	...	...	...	·071
·0024	...	46	...	...	...	·061
·0020	...	47	...	...	...	·051
·0016	...	48	...	...	...	·041
·0012	...	49	...	...	...	·030
·0010	...	50	...	...	...	·025

JEWELLER'S GAUGE (SHAKESPEARE).

Numbers . .	0000	000	00	0	1	2	3
Decimals of inch .	·0035	·004	·0045	·005	·0055	·006	·0065
Millimètres . .	·090	·102	·115	·127	·140	·152	·165
Numbers . .	4	5	6	7	8	9	10
Decimals of inch .	·0075	·0085	·0095	·0105	·012	·014	·016
Millimètres . .	·191	·216	·242	·267	·305	·356	·406
Numbers . .	11	12					
Decimals of inch .	·019	·0215					
Millimètres . .	·483	·546					

COMPARATIVE TABLE OF THE VARIOUS GAUGES—*continued.*

Decimals of inch.	B'ghm Metal Gauge.	I. Standard Wire Gauge.	Morre Twist Drill and Steel Wire Gauge.	Stubs' Iron Wire Ga. or B'ghm Wire Gauge.	Stubs' Steel Wire Gauge.	Milli-mètres.
·0595	...	...	53	...	...	1·51
·059	18	...	...	...	...	1·50
·058	...	...	...	17	53	1·47
·056	...	17	...	...	...	1·42
·055	17	...	54	...	54	1·40
·052	...	...	55	...	...	1·32
·051	16	...	...	...	...	1·30
·050	...	...	...	...	55	1·27
·049	...	...	...	18	...	1·24
·048	15	18	...	...	...	1·22
·0465	...	...	56	...	...	1·18
·045	...	...	...	...	56	1·14
·043	14	...	57	...	...	1·09
·042	...	...	58	19	57	1·07
·041	...	...	59	...	58	1·04
·040	...	19	60	...	59	1·02
·039	...	...	61	...	60	·99
·038	13	...	62	...	61	·97
·037	...	...	63	...	62	·94
·036	...	20	64	...	63	·91
·035	12	...	65	20	64	·89
·033	...	...	66	...	65	·84
·032	11	21	67	21	66	·81
·031	...	...	68	...	67	·79
·030	...	...	...	...	68	·76
·02925	...	...	69	...	...	·74
·029	...	...	...	...	69	·74
·028	10	22	70	22	...	·71
·027	...	...	...	...	70	·69
·026	...	...	71	...	71	·66
·025	...	...	72	23	...	·63
·024	9	23	73	...	72	·61
·023	...	...	...	...	73	·58
·0225	...	...	74	...	...	·57
·022	...	24	...	24	74	·56
·0215	8	...	...	...	...	·55
·021	...	...	75	...	...	·53
·020	...	25	76	25	75	·51
·019	7	...	...	...	...	·48
·018	...	26	77	26	76	·46
·0164	...	27	...	...	...	·42
·016	6	...	78	27	77	·41
·015	...	...	...	...	78	·38
·0148	...	28	...	...	...	·38
·0145	...	...	79	...	...	·37
·0140	5	...	...	28	79	·36

371. Tazza and cover of iron. A very graceful shape in this difficul material. Modern Belgian. S.K.M.

372. Candlestick of bronze, damascened in silver. Perfect in form an treatment. Venetian Saracenic work, about 1550. S.K.M.

373–4. The Tara Brooch. 3⅝ inches diameter. Gold, silver, niello enamel, amber and glass, are all employed on this most dainty piece of work. Perhaps the most beautiful brooch in the world Irish, about tenth century. National Museum, Dublin.

375. The Kilmainham Brooch. The red stones and gold filigree work make a charming contrast to the strong outline. Irish.

376. Anglo-Saxon Buckle found at Taplow. Gold, set with garnets and green glass. Notice the rich effect obtained by the twisted wires, and the contrast between them and the red stones. The importance of the design in the central panel is enhanced by the repoussé work under the wires. The latter would be soldered to the thin gold plate, and all the background afterwards tapped down. B.M.

377. Gold bowl. The patterns here are made from a double row of gold grains soldered to the body of the bowl. The bold repoussé flutes contrast well with the finer work. Etruscan. S.K.M.

378. Gold necklace of vases pendant from chain. On this necklace are some of the earliest enamels. They are the ring, disc and heart shapes above the vases. Very delicate Greek work from Melos. Second century, B.C. B.M.

The gold ring is of the finest Greek type, with fine wire patterns.

379. Gold brooch. Probably Othonian work. Filigree, cloisonné enamels and pearls. Tenth or eleventh century. B.M.

Gold brooch. Delightful variety of surface and line. Teutonic B.M.

380. The St. Agnes Cup. Gold and bassetaille enamels. French work of the fourteenth century. The finial is missing, as also is a band of ornament with pearls which ran round the lid. The stem is a later addition. One of the most perfect examples of goldsmiths' work in the world. B.M.

381. Beaker and cover with plique à jour enamels. Graceful in outline and beautiful in workmanship, every part of this splendid work shows the skill and taste of the craftsman who made it. Notice the little leaves at the corners of the mouldings and the diaper over all the plain surface. Burgundian (?) work. S.K.M.

382. Cross with plique à jour enamels in high relief, pearls and diamonds. See page 194. S.K.M.

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Workshop Receipts, ERNEST SPON, Five Volumes. (Spon.) 1895.

FIG. 359.—Beaker. S. German. Fifteenth century.

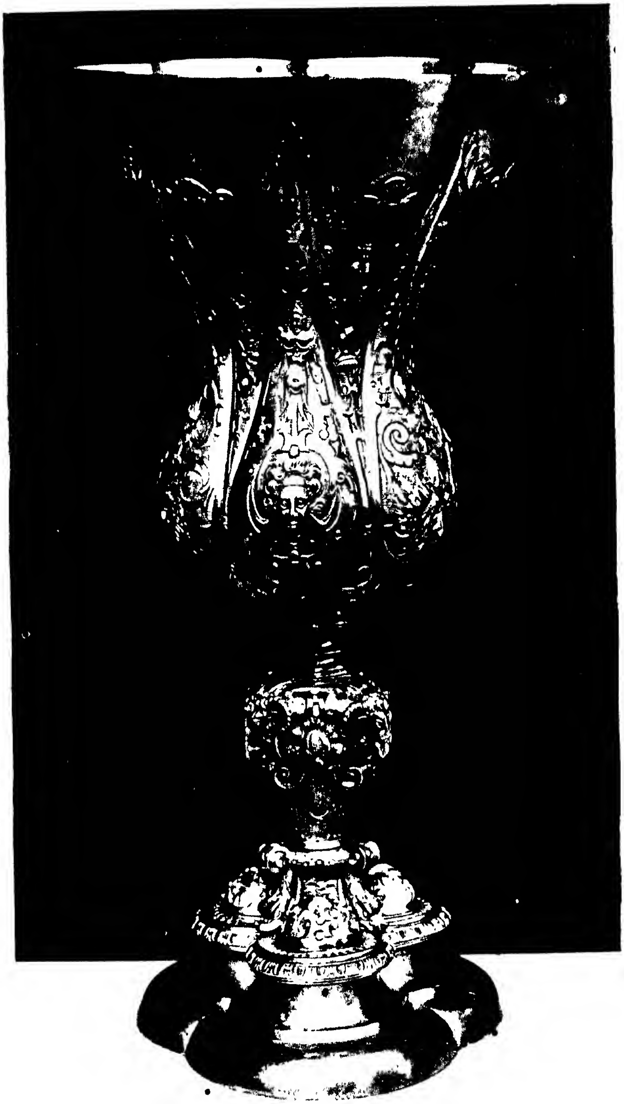


FIG. 360. Silver cup. Nuremberg. Sixteenth century.

Photo Chas. Lowe.]
FIG. 361.—Bronze clasp for cuirass. Greek.

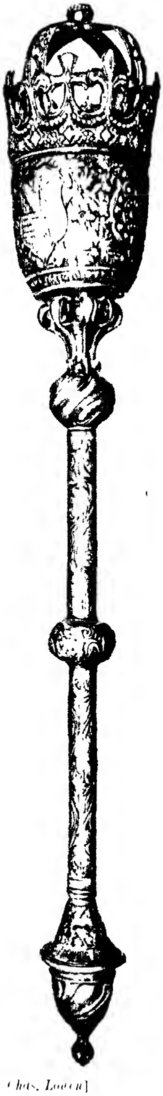


Photo Chas. Lowen]

FIG. 362.—Mace. Modern English.

Photo Chas. Lowen

Fig. 363.—Detail of mace (Fig. 362).

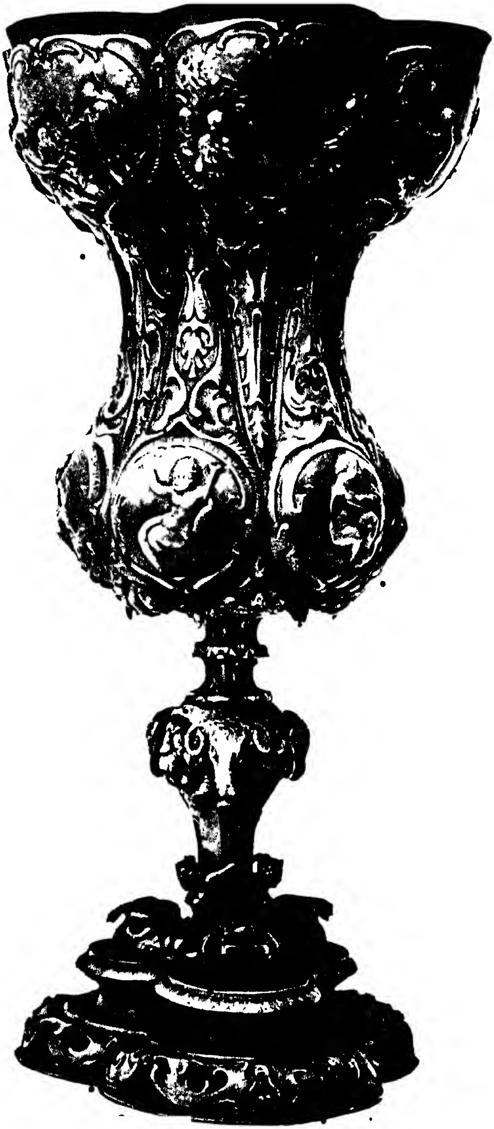


Photo: Chas. Lowen]

FIG. 361.—Cup. German. Sixteenth century.

FIG. 265. Wine-cup. English. Sixteenth century.

Photo. [illegible]

FIG. 366.—Wine-cup. French. Sixteenth century.

Fig. 367.—Chalice. Fifteenth century.

Photo: Chas. Louen.]

Fig. 368.—Greek bowl. Fourth century B.C. Silver

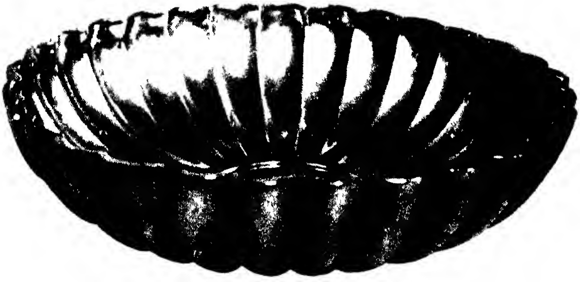


Photo: Chas. Louen.]

Fig. 369.—Bowl. Treasure of Chaourse. Second century A.D.

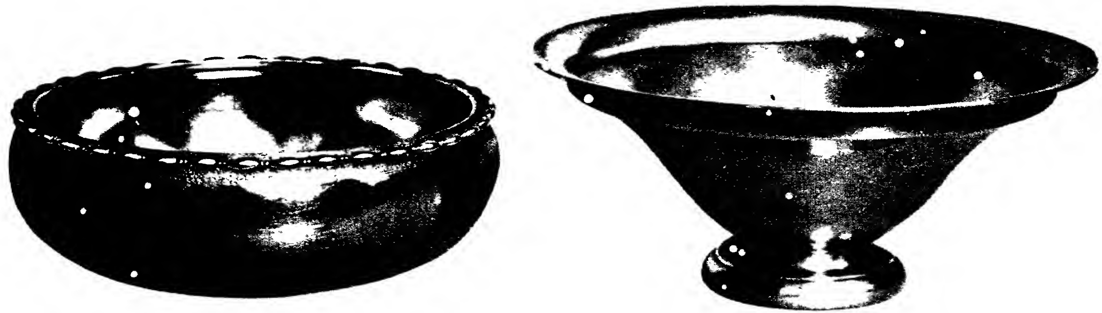


Photo: Chas. Lowell

FIG. 370.—Bowl Treasure of Chaourse. Second century A.D. Bowl Treasure of Hildesheim.

Fig. 371.—Tazza and cover. Modern Belgian. Iron.

Photo: Chas Lowen]

FIG 372.—Candlestick. Bronze, damascened silver. Venetian. Sixteenth century.

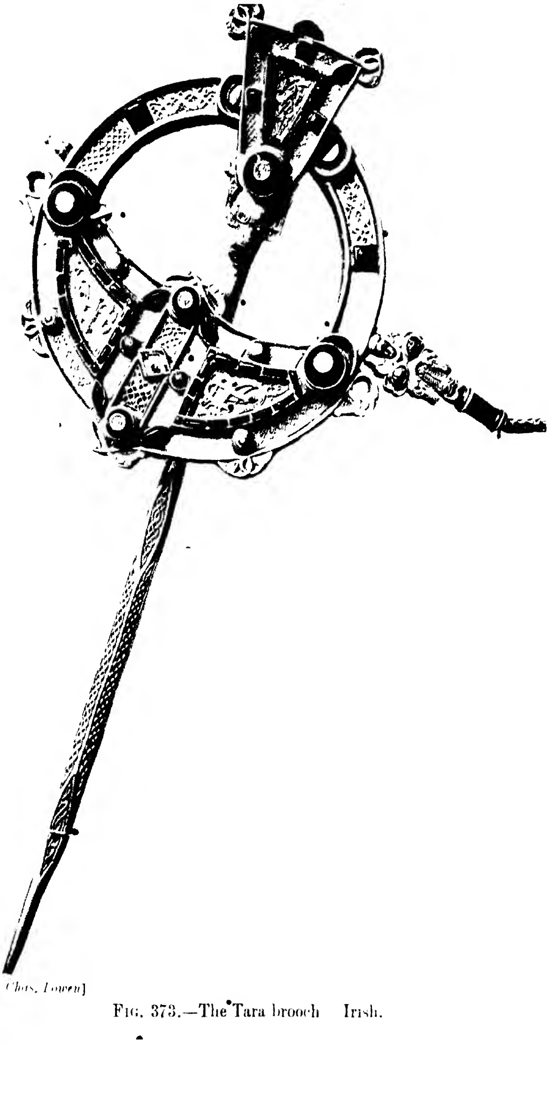


Photo., Chas. Lowen]

FIG. 373.—The Tara brooch. Irish.

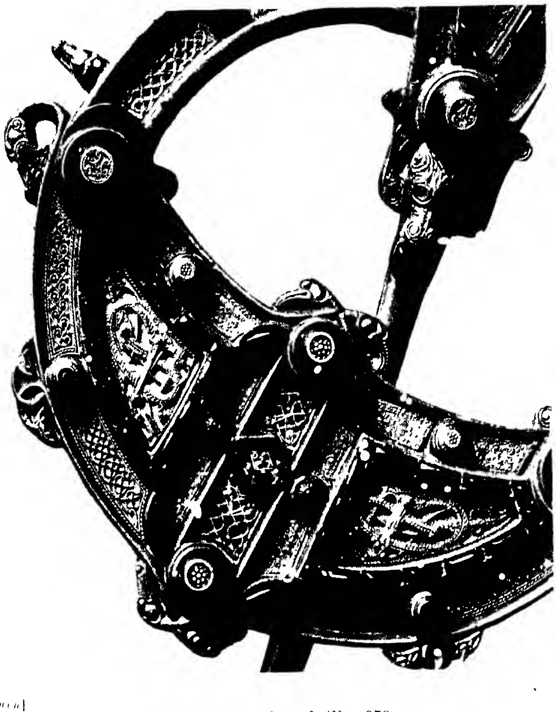


Photo Chas Lovett]

FIG. 374.—Detail of the Tara brooch (Fig 373).

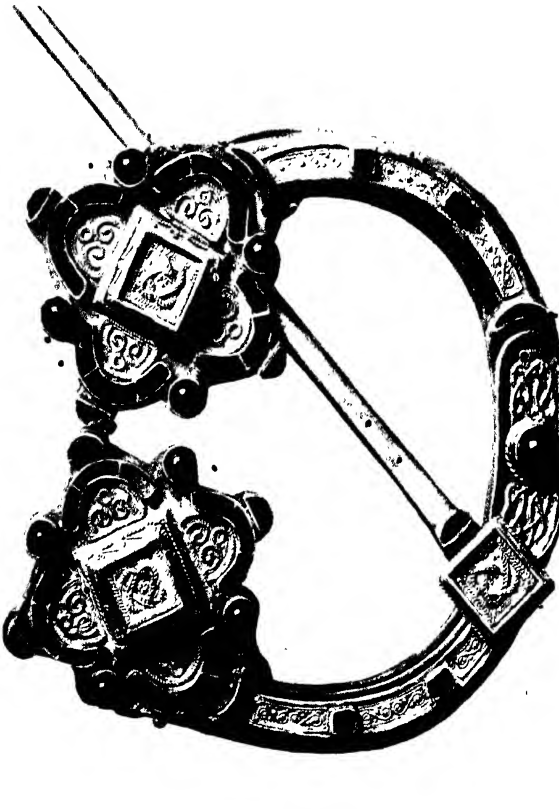


Photo Chas. Lowen]

FIG. 37[illegible]. The Kilmainham brooch. Irish.

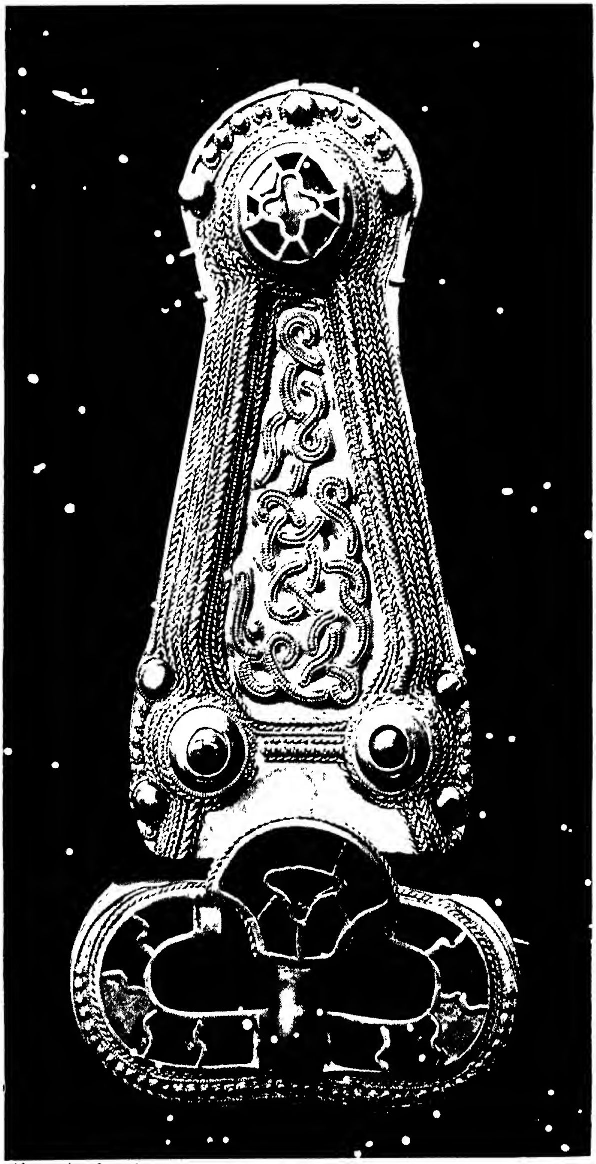


Photo: Cho. Lewis]

FIG. 376.—Anglo-Saxon buckle. Gold.

Fig. 377.—Gold bowl. Etruscan.

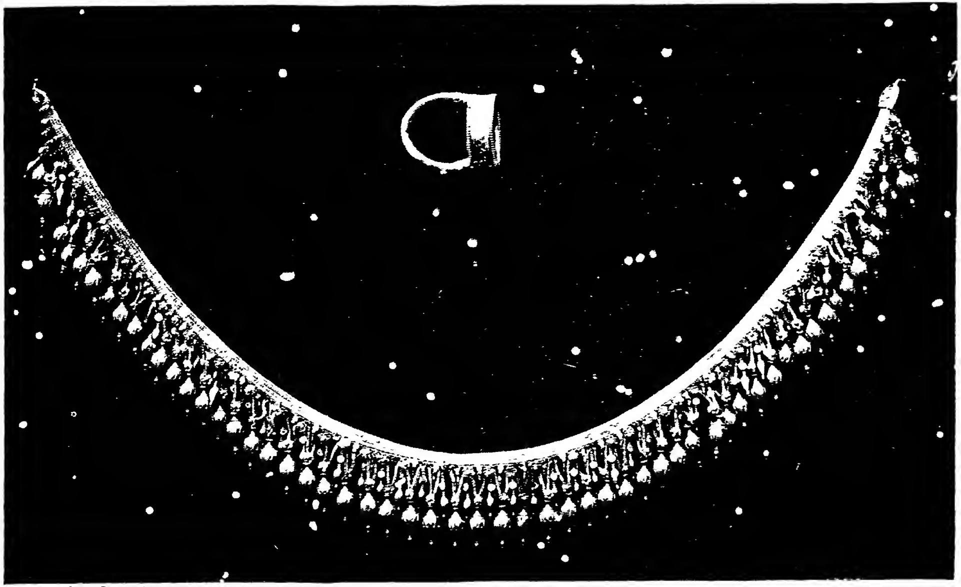
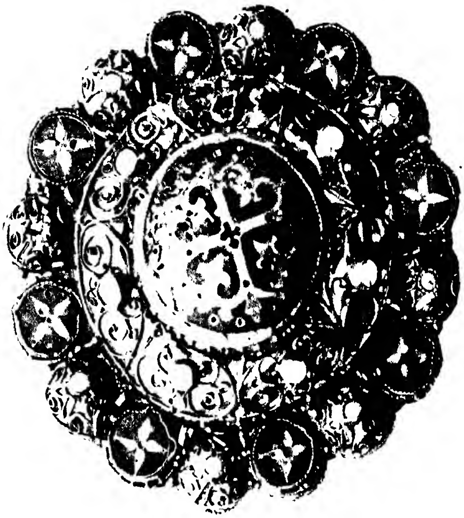


Photo: Chas. Jones.]

FIG. 378.—Gold necklace from Melos. Second century B.C. Gold ring from Tarentum.



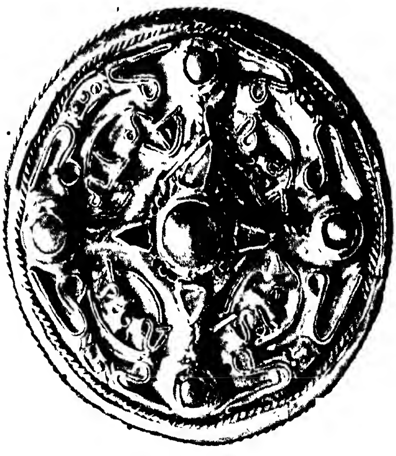


Photo Chas. Lowen]

FIG. 379.—Gold brooch. Othonian. Tenth to eleventh century.
Gold brooch. Teutonic.

FIG. 380.—The St. Agnes cup. Gold and enamel.

Photo Chas. Powell

FIG. 381.—Beaker. Silver and enamel. Burgundian. Fourteenth century.

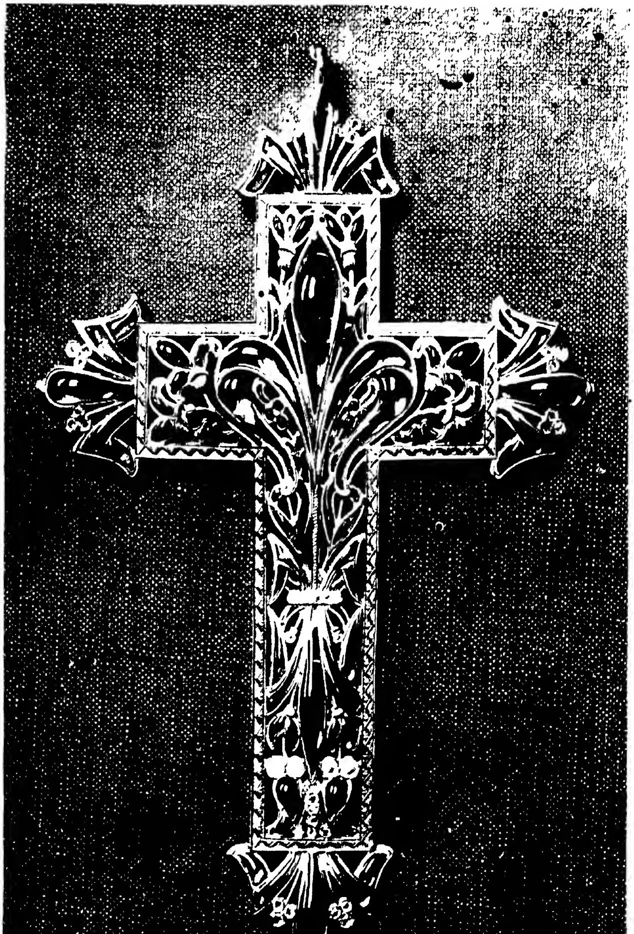


FIG. 382.—Cross. Silver and enamel.

INDEX

Where several pages are given, those on which the more important references are to be found are placed first.